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LONGMAN, BROWN, GREEN, AND LONGMANS,

PATERNOSTER-ROW.

MDCCCXLV.

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† The following abbreviations are made use of:—Carb., Carboniferous series; Cret., Cretaceous; G. S., Greensand; and L. G. S., Lower Greensand.—Eocene, f. w. signifies Freshwater beds of the older Tertiary period.

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<i>Melania Hamiltoniana</i> . Edw. Forbes.	Eocene, f. w.	Vourla, Smyrna -	164
— <i>sp.</i> (Cast) - - -	Eocene, f. w.	Jacksonboro', Georgia	439
<i>Natica sp.</i> (Cast) - - -	Cret. -	New Jersey, U. S. -	63
<i>Oliva sp.</i> (Cast) - - -	Eocene -	Wilmington, N. Carolina, U. S.	431
* <i>Paludina vivipara</i> - - -	Eocene, f. w.	New Cross, Kent -	173
— <i>Stricklandiana</i> . E. Forbes	Eocene, f. w.	Vourla, Smyrna -	164
— <i>sp.</i> (Cast) - - -	Eocene, f. w.	Wilmington, N. Carolina, U. S.	431
<i>Planorbis Spratti</i> . Edw. Forbes.	Eocene, f. w.	Vourla, Gulf of Smyrna	163
<i>Pleurotomaria Anstedii</i> . Edw. Forbes. Pl. v. f. 1.	L. G. S. -	Nutfield, Surrey -	349
<i>Pterocera Fittoni</i> . Edw. Forbes. Pl. iv. f. 6.	L. G. S. -	Atherfield - -	351
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* <i>Tornatella marginata</i> . Pl. iv. f. 1.	L. G. S. -	Atherfield, &c. -	347
— <i>sp.</i> (Cast) - - -	Cret. -	New Jersey, U. S. -	63
* <i>Trochus albensis</i> - - -	L. G. S. -	Peasemarsch - -	348
* — <i>decussatus</i> - - -	L. G. S. -	Maidstone - -	348
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<i>Voluta</i> . (Casts of 3 species) -	Cret. -	New Jersey, U. S. -	63

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— <i>Buchiana</i> . Edw. Forbes -	Cret. - -	Santa Fe - -	177
* — <i>Deshayesii</i> . Pl. v. f. 2. -	L. G. S. -	Atherfield, &c. -	354
— <i>Hambrovii</i> . Edw. Forbes. Pl. v. f. 4.	L. G. S. -	Atherfield - -	354
— <i>Hopkinsi</i> . Edw. Forbes.	Cret. -	Santa Fe - -	176
— <i>Inca</i> . Edw. Forbes -	Cret. -	Santa Fe - -	177
— <i>Leai</i> . Edw. Forbes -	Cret. -	Santa Fe - -	178
* — <i>Martini</i> . Pl. v. f. 3. -	L. G. S. -	Atherfield - -	354
* <i>Ancylloceras Humboldtiana</i> -	Cret. -	Santa Fe - -	175
* <i>Belemnites Owenii</i> . Pratt -	Oxford clay	Wilts - -	119
<i>Hamites Orbignyana</i> . Edw. Forbes.	Cret. -	Santa Fe - -	175
* <i>Nautilus radiatus</i> . Var. <i>Neocomiensis</i> .	L. G. S. -	Atherfield, &c. - -	353
* <i>Scaphites grandis</i> (<i>Hamites sp.</i>)	L. G. S. -	Atherfield - -	355

Name of Species.	Formation.	Locality.	Page.
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<i>Aspidorhynchuseuodus</i> . Egerton. (Part of jaw.)	Oxford clay	Christian Malford	231
<i>Corax incisus</i> . Eg. (Tooth.) -	Cret. -	Pondicherry	168
* <i>pristodontus</i> . (Tooth.) -	Cret. -	Pondicherry	167
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— <i>sigmoides</i> . Eg. (Teeth.)	Cret. -	Pondicherry	170
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<i>Leptolepis costalis</i> . Egerton	Oxford clay	Christian Malford	231
— <i>macrophthalmus</i> . Egerton	Oxford clay	Christian Malford	231
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— <i>oxyprion</i> . Eg. (Tooth.)	Cret. -	Pondicherry	171
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— <i>divergens</i> . Eg. (Tooth.)	Cret. -	Pondicherry	169
— ? <i>marginatus</i> . Eg. (Teeth.)	Cret. -	Pondicherry	168
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— <i>nanus</i> . Egerton. (Teeth.)	Cret. -	Pondicherry	169
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* <i>Dicynodon lacerticeps</i> . Owen	?	S. Africa	318
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<i>Bramatherium Perimense</i> . Fal- coner. (Teeth.) Pl. 14. f. 3, 4.	Tertiary -	Perim Island	363
* <i>Camelopardalis Sivalensis</i> ? Fal- coner. (Vertebra.) Pl. 14. f. 5.	Tertiary -	Perim Island	362
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* The binder should be instructed to place these five plates of Lower Greensand fossils together at the end of the volume, with the page of description corresponding to them, immediately before the Alphabetical Index.

CORRIGENDA ET ERRATA.

- In page 15. the whole of the last paragraph should appear in small type at the end of the note in the same page.
- In page 18. line 14., for the words *lower, middle, and upper flags*, substitute the words *Upper Silurian Rocks*.
- In the same page, line 17., for *flags* substitute *part of the upper Silurian series*.
- In page 19. line 1., dele the word *lower*.
- In the same page, line 11. from the bottom, instead of the sentence beginning with the word *flags* in that line, and ending with the word *fossils* in line 9. from the bottom, substitute *portion of the upper series consists of a great thickness of Denbigh flagstone*.
- In page 20., dele the first three lines, and as far as the word *bed* in line 4., and substitute *A bed occurs*.
- In the same page, line 10., for *flags* substitute *parts of the upper series*; and in line 13., after the word *from* insert *beneath*.
- In page 39. line 3. from bottom, for "British and Fossil Mammalia," read "British Fossil Mammalia."
- In page 234. line 2. from bottom, for "*Mem. de l'Institut*," read "*Institut*."
- In page 300., Title of Article 2. line 2., for SOUTH WALES, read NORTH WALES.
- In page 347., species 114., for *Amullaria* read *Ampullaria*.
- In page 347., species 116., line 5., for *spine* read *spire*.
- In page 347., species 121., for *Dupineana* read *Dupiniana*.
- In page 350., species 134., line 2., for *seperioribus* read *superioribus*.
- In page 352., species 138., line 5., for *angustivé* read *angustior*.
- In page 352., species 138., line 10., for *branch* read *much*.
- In page 353., species 150., for *Schlotteim* read *Schlotheim*.
- In page 354., species 151., for *Martiniü* read *Martini*.
- In page 360. line 25., for *Dinotherum* read *Dinotherium*.
- In page 392. line 7., for CANADA read NORTH AMERICA.
- In page 392. line 14., for CANADAS read BRITISH POSSESSIONS IN NORTH AMERICA.
- In page 393. line 32., and in various other places throughout the article, for *the Minudie* read *Minudie*, Minudie being a village and not a river.
- In page 394. line 32., dele *River*.
- In page 402., at the end of the article on Fossil Insects, insert D.T.A.
- In page 407. title, line 1., for SILURIAN read CARBONIFEROUS.
- In page 407. title, line 2., insert *and* after the word TOWN. Elsewhere in the same page the names *New South Wales* and *Van Diemen's Land* should be interchanged.
- In page 450. line 8. from bottom, for HERTS read HANTS.
- In page 543. line 15. from top, for "*Drontheim*" read "*Trondiem*."

• *Corrigenda in the Plates.*

In the map of Nova Scotia by Dr. Gesner (Plate ii.) the gypsiferous district near Truro has been inadvertently left of the same colour as the Old Red Sandstone.

In the same map the portion stated to be copied from Mr. Dawson's survey is very imperfect, but is corrected in plate x., where Mr. Dawson's map is given in detail.

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50.	HORNER, Leonard, F.R.S. <i>On the Geology of the Environs of Bonn</i> , pp. 49., large plate containing coloured map, coloured outline, and organic remains - - - [iv. 8.	5 0	7 0
51.	HUNTON, Louis. <i>Remarks on the Section of the Upper Lias and Marlstone of Yorkshire, showing the limited vertical Range of the Species of Ammonites and other Testacea, with their Value as Geological Tests</i> , pp. 7. [v. 18.	1 0	1 6
52.	LOGAN, W. E., F.G.S. <i>On the Characters of the Beds of Clay immediately below the Coal Seams of South Wales, and on the Occurrence of Boulders of Coal in the Pennant Grit of that District</i> , pp. 7. [vi. 29.	1 6	2 0
53.	LONSDALE, William, F.G.S. <i>On the Oolitic District of Bath</i> , pp. 36., coloured section - - [iii. 14.	5 0	7 0
54.	——— <i>Notes on the Age of the Limestone of South Devonshire</i> , pp. 18. - - - [v. 46.	2 6	3 6
55.	LYELL, Chas., F.R.S. <i>On a recent Formation of Fresh-water Limestone in Forfarshire, and on some recent Deposits of Fresh-water Marl, with a Comparison of recent with ancient Fresh-water Formations, and an Appendix on the Gyrogonite or Seed-vessels of the Chara</i> , pp. 24., coloured map and plate [ii. 8.	6 0	8 6

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56.	LYELL, Chas., F.R.S. <i>On the Strata of the Plastic Clay Formation in the Cliffs between Christchurch Head, Hampshire, and Studland Bay, Dorsetshire; and on the Freshwater Strata of Hordwell Cliff, Beacon Hill, and Barton Cliff, Hampshire</i> , pp. 14., coloured map - - - - - [ii. 18. 19.	5 0	7 0
57.	— <i>On the Cretaceous and Tertiary Strata of the Danish Islands of Seeland and Moen</i> , pp. 15. plate and 11 woodcuts - - - - - [v. 20.	3 0	3 6
58.	— <i>Remarks on some Fossil and recent Shells collected by Capt. BAYFIELD, R.N., in Canada</i> , pp. 7. and plate - - - - - [vi. 8.	2 0	2 6
59.	MACLAUCHLAN, H., F.G.S. <i>Notes to accompany a Geological Map of the Forest of Dean Coalfield</i> , pp. 12., large coloured map and 2 woodcuts - - - - - [v. 16.	1 6	2 0
60.	— <i>Notes to accompany some Fossils collected by the Author and Mr. H. Still during their employment on the Ordnance Survey of Pembrokeshire</i> , pp. 4., 2 woodcuts of sections - - - - - [vi. 34.	0 6	1 0
61.	MALCOLMSON, J. G., F.G.S. <i>On the Fossils of the Eastern Portion of the great Basaltic District of India</i> , pp. 39., large coloured map, plate of sections, and plate of fossils - - - - - [v. 38.	4 0	5 6
62.	MANTELL, G. A., LL.D., F.R.S. <i>A Tabular Arrangement of the Organic Remains of the County of Sussex</i> , pp. 16. - - - - - [iii. 10.	1 6	2 0
63.	— <i>On the Bones of Birds discovered in the Strata of Tilgate Forest in Sussex</i> , pp. 3. plate - - - - - [v. 13.	1 0	1 6
	— <i>Description of the Fossil Fox of Æningen</i> . See 68.		
64.	MARTIN, Capt., J. B., R.N. <i>Description of Bones of the Mammoth found in the deep Sea of the British Channel and German Ocean</i> , pp. 3. - - - - - [vi. 12.	0 6	1 0
65.	MILLER, J. S. <i>Observations on Belemnites, and Observations on the Genus Actinocamax</i> , pp. 24. 3 plates - - - - - [ii. 5, 6.	4 6	6 0
66.	MURCHISON, R. I., F.R.S., P.R. Geog. S. <i>Geological Sketch of the North Western Extremity of Sussex and adjoining Parts of Hants and Surrey</i> , pp. 12., coloured map and plate - - - - - [ii. 9.	3 0	4 0
67.	— <i>On the Coal Field of Brora in Sutherlandshire and some other stratified Deposits in the North of Scotland, with supplementary Remarks on these Strata and the Rocks associated with them in Ross-shire and in the Hebrides</i> , pp. 50., map and 2 plates - - - - - [ii. 20. 23.	8 6	12 0
68.	— <i>On a Fossil Fox, found at Æningen, near Constance, with an Account of the Deposit in which it was imbedded, and an anatomical Description of the Fox by Dr. MANTELL</i> , pp. 16., and 2 large plates - - - - - [iii. 15, 16.	4 0	5 6
69.	— and H. E. STRICKLAND, F.G.S. <i>On the upper Formations of the New Red Sandstone system in Gloucestershire, Worcestershire, and Warwickshire, showing that the Red or Saliferous Marls, including a</i>		

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	<i>peculiar Zone of Sandstone, represent the Keuper or Marnes irisées; with some Account of the underlying Sandstone of Ombersley, Bromsgrove, and Warwick, proving that it is the Bunter Sandstein or gres bigarré of foreign geologists, pp. 18., coloured map and large plate of fossils</i> - - - [v. 26]	2 6	3 6
	MURCHISON, R. I., F.R.S., <i>Geology of the Isle of Arran.</i> See 98.		
	— <i>On the Old Red Sandstone of Scotland.</i> See 99.		
	— <i>Structure of the Eastern Alps.</i> See 100.		
	— <i>Raised Beach at Barnstaple.</i> See 101.		
	— <i>Physical Structure of Devonshire.</i> See 102.		
	— <i>Palæozoic Rocks of Germany.</i> See 103.		
70.	NELSON, Lieut. K. J. <i>On the Geology of the Bermudas, pp. 21., and coloured map</i> - - - [v. 5.]	2 6	3 6
71.	OWEN, Richard, F.R.S., Hunterian Professor in the Royal College of Surgeons. <i>Note on the Dislocation of the Tail at a certain Point observable in the Skeleton of many Ichthyosauri, pp. 4. 1 large plate</i> [v. 36.]	2 6	3 6
72.	— <i>Description of a Specimen of Plesiosaurus macrocephalus, in the Collection of the Earl of Enniskillen, pp. 21. 3 Plates</i> - - - [v. 37.]	5 6	7 6
73.	— <i>Description of some Fossil Remains of Chæropotamus, Palæotherium, Anoplotherium, and Dichobunes, from the Eocene Formation, Isle of Wight, pp. 5, and one large plate</i> - - - [vi. 2.]	2 6	3 6
74.	— <i>Observations on the Fossils representing the Thylacotherium Prevostii, with reference to the Doubts of its Mammalian and Marsupial Nature recently promulgated, and on the Phascolotherium Bucklandi, pp. 19, 2 plates</i> - - - [vi. 3.]	5 0	7 0
75.	— <i>Observations on the Basilosaurus of Dr. Harlan (Zeuglodon cetoides Owen), and a Letter from Dr. HARLAN on the Discovery of the Remains of the Basilosaurus or Zeuglodon, pp. 13., 3 plates</i> [vi. 4, 5.]	4 6	6 0
76.	— <i>Description of a Tooth and Part of the Skeleton of Glyptodon clavipes, with a Consideration of the question whether the Megatherium possessed an analogous dermal Armour, pp. 26., 4 plates</i> - [vi. 6.]	7 6	10 0
77.	— <i>A Description of some of the soft Parts, with the Integument of the Hind Fin of the Ichthyosaurus, indicating the Shape of the Fin when recent, pp. 3., plate</i> - - - [vi. 19.]	2 6	3 6
78.	— <i>Description of the Fossil Remains of a Mammal (Hyracotherium leporinum), and a Bird (Lithornis vulturinus), from the London Clay, pp. 6., one plate</i> [vi. 20.]	3 0	4 0
79.	— <i>Description of some Ophidiolites (Palæophis toliapicus), from the London Clay of Sheppey, indicative of an extinct Species of Serpent, pp. 2., plate</i> [vi. 21.]	2 0	2 6

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80.	OWEN, Richard, F.R.S. <i>Description of the Remains of a Bird, a Tortoise, and a Lizard from the Chalk</i> , pp. 3., plate - - - [vi. 26.	2 6	3 6
81.	— <i>On the Teeth of Species of the genus Labyrinthodon (Mastodonsaurus of Jäger), common to the German Keuper Formations and the Lower Sandstone of Warwick and Leamington; and Description of Parts of the Skeleton and Teeth of five Species of Labyrinthodon, with Remarks on the probable Identity of the Chirotherium with this extinct Genus of Reptiles</i> , pp. 40., 2 woodcuts and 5 plates [vi. 31, 32.	12 6	16 0
82.	PENTLAND, J. B. <i>Description of Fossil Remains of some Animals from the North East Border of Bengal</i> , pp. 2., and one plate - - - [ii. 26.	0 6	1 0
83.	PHILLIPS, John, F. R. S. <i>On a Group of Slate Rocks ranging E. S. E. between the Rivers Lune and Wharfe, from near Kirby Lonsdale to near Malham, and on the attendant Phenomena</i> , pp. 19, 1 coloured map and section - - - [iii. 1.	2 6	3 6
84.	PRATT, Samuel Peace, F. R. S. <i>Remarks on the Existence of Anoplotherium and Palæotherium in the lower Fresh-water Formations at Binstead near Ryde, in the Isle of Wight</i> , pp. 3. - - - [iii. 23.	0 6	1 0
85.	PRESTWICH, Jos., F. G. S. <i>On the Structure of the Neighbourhood of Gamrie, Banffshire, particularly on the Deposit containing Ichthyolites</i> , pp. 10., one Plate containing map and coloured sections, and woodcuts - - - [v. 10.	2 6	3 6
86.	— <i>On the Geology of Colebrook Dale</i> , pp. 83., large map, large plate of coloured sections, large plate of sections, and 4 plates of Organic Remains [v. 33.	10 0	13 6
	PROUT, Dr. <i>Analysis of Fossil Faeces of Ichthyosaurus</i> - - - See 17.		
87.	RICHARDSON, William, F. G. S. <i>Observations on the Locality of the Hyracotherium</i> , pp. 4. - [vi. 22.	0 6	1 0
88.	RILEY, H., M.D. <i>On the Squaloraria</i> , pp. 6. plate. [v. 3.	1 0	1 6
89.	— and Mr. Sam. STUTCHBURY. <i>A Description of Various Fossil Remains of three distinct Saurian Animals, recently discovered in the Magnesian Conglomerate near Bristol</i> , pp. 9., 2 plates of fossils [v. 27.	3 0	4 6
90.	ROFE, J. <i>Observations on the geological Structure of the Neighbourhood of Reading</i> , pp. 4. - - [v. 7.	0 6	1 0
91.	SCROPE, J. Poulet, F.R.S. <i>Notice on the Geology of the Ponza Islands</i> , pp. 42., col. map, 2 plates [ii. 14.	6 6	8 6
92.	— <i>On the Volcanic District of Naples</i> , pp. 16. one plate of maps, sections, and views [ii. 22.	3 0	4 6
93.	SEDGWICK, Rev. Professor, F.R.S. <i>On the Geological Relations and internal Structure of the Magnesian Limestone, and the lower Portions of the New Red Sandstone Series, in their Range through Nottinghamshire, Derbyshire, Yorkshire, and Durham, to the southern Extremity of Northumberland</i> , pp. 90. coloured maps and sections, and 5 plates of fossils. [iii. 3.	10 6	13 6

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94.	SEDGWICK, Rev. Professor, F.R.S., <i>Remarks on the Structure of large Mineral Masses, and especially on the Chemical Changes produced in the Aggregation of stratified Rocks, during different Periods after their Deposition</i> , pp. 26., plate - [iii. 25.	5 0	7 0
95.	— <i>Introduction to the general Structure of the Cumberland Mountains, with a Description of the great Dislocations by which they have been separated from the neighbouring Carboniferous Chains</i> , pp. 22. coloured map, plate of coloured sections - [iv. 2.	3 6	5 0
96.	— <i>Description of a Series of longitudinal and transverse Sections through a Portion of the Carboniferous Chain between Penignt and Kirby-Stephen</i> , pp. 34. one large plate of col. sections [iv. 3.	3 6	5 0
97.	— <i>On the New Red Sandstone Series of the Basin of the Eden, and North-Western Coasts of Cumberland and Lancashire</i> , pp. 25., large plate of coloured sections - - - [iv. 6.	3 6	5 0
98.	— and R. I. MURCHISON, Esq. F.R.S. <i>On the Geological Relations of the secondary Strata of the Isle of Arran</i> , pp. 16., and one long coloured section - - - [iii. 2.	3 0	4 6
99.	— <i>On the Structure and the Relations of the Deposits contained between the primary Rocks and the Oolitic Series in the North of Scotland</i> , pp. 36., coloured map, coloured section, and 3 plates of Organic Remains - [iii. 4.	5 0	7 0
100.	— <i>A Sketch of the Structure of the Eastern Alps, with Sections through the newer Formations on the northern Flanks of the Chain, and through the Tertiary Deposits of Styria, &c.</i> , pp. 124., coloured map, a series of coloured sections, and 4 plates - - - [iii. 18.	7 6	10 0
101.	— <i>Description of a raised Beach in Barnstaple, or Bideford Bay, on the North West Coast of Devonshire, with an Extract from a Letter on the same Subject, by the Rev. D. WILLIAMS</i> , pp. 10. and 2 woodcuts - [v. 23, 24.	1 0	1 6
102.	— <i>On the Physical Structure of Devonshire, and on the Subdivisions and Geological Relations of its older stratified Deposits</i> , pp. 73., large coloured map, large plate of coloured sections, and 7 plates of fossils - - [v. 43.	10 0	13 6
103.	— <i>On the Disturbances and Classification of the older or Palæozoic Deposits of the North of Germany and Belgium, and their Comparison with Formations of the same Age in the British Isles. With a Memoir, by M. de VERNEUIL and the Conte d'ARCHIAC, On the Fossils of the older Deposits in the Rhenish Provinces, preceded by a General Survey of the Fauna of the Palæozoic Rocks, and followed by a Tabular List of the Organic Remains of the Devonian System in Europe</i> , pp. 189., large coloured map, large plate of coloured sections, and 14 plates of Organic Remains - [vi. 24, 25.	27 6	35 0

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104.	SHARPE, Daniel, F. L. S. <i>On the Geology of the Neighbourhood of Lisbon</i> , pp. 27., coloured map, large plate of coloured sections - [vi. 7.	3 6	5 0
	SMEE, Capt. <i>Fossils collected by</i> . See 115.		
105.	SMITH, James, of Jordan Hill, F. R. S. <i>On the relative Ages of the Tertiary and Post-tertiary Deposits of the Basin of the Clyde</i> , pp. 4. - [vi. 10.	0 6	1 0
106.	SOWERBY, Jas. de C. <i>On the Genus Crioceratites, and on Scaphites gigas</i> , pp. 3., plate - - [v. 32.	1 6	2 0
107.	STOKES, Charles, F. R. S. <i>Notice respecting a Piece of recent Wood partly petrified by Carbonate of Lime, with some Remarks on Fossil Woods</i> , pp. 8., 2 plates and woodcut - - - [v. 17.	2 6	3 6
108.	——— <i>On some Species of Orthocerata</i> , pp. 10., and 2 plates - - - [v. 44.	2 6	3 6
109.	STRICKLAND, H. E. <i>On the Geology of the Thracian Bosphorus</i> , pp. 7., 3 woodcuts - - [v. 29.	2 0	2 6
110.	——— <i>On the Geology of the Neighbourhood of Smyrna</i> , pp. 10., with a coloured map and sections [v. 30.	2 6	3 6
111.	——— <i>On the Geology of the Island of Zante</i> , pp. 7., coloured map and sections - - [v. 31.	2 6	3 6
112.	——— <i>On some remarkable Dykes of Calcareous Grit at Ethie, in Ross-shire</i> , pp. 2. - - [v. 41.	0 6	1 0
113.	——— <i>Memoir descriptive of a Series of coloured Sections of the Cuttings on the Birmingham and Gloucester Railway</i> , pp. 11., large plate of coloured sections - - - [vi. 33.	3 0	4 6
	——— <i>Geology of the Western part of Asia Minor</i> . See 46.		
	——— <i>On the New Red Sandstone of the Middle of England</i> . See 69.		
	STUTCHBURY, S. <i>Saurians of the Magnesian Conglomerate</i> . See 89.		
114.	SYKES, Lieut.-Col. W. H., F. R. S. <i>On a Portion of the Dukhun, East Indies</i> , pp. 24., map and 2 large plates of sections - - - [iv. 7.	3 6	4 6
115.	——— <i>Notice respecting some Fossils collected in Cutch by Capt. W. SMEE</i> , pp. 5., and plate - [v. 45.	1 6	2 0
116.	TAYLOR, J., F. G. S. <i>Observations on the Strata penetrated in sinking a Well at Diss, in Norfolk</i> , pp. 2. [v. 9.	0 6	1 0
117.	TAYLOR, R. C., F. G. S. <i>Notice of Models of Part of the Mineral Basin of South Wales, in the Vicinity of Pontypool</i> , pp. 4. - - - [iii. 21.	0 6	1 0
	VERNEUIL, M. E., and Conte d'ARCHIAC. <i>Palæozoic Fossils of the Rhenish Provinces</i> [vi. 25. See 103.		
118.	VERSCHOYLE, The Ven. Archdeacon. <i>Notices on the Geology of the North Coast of the Counties of Mayo and Sligo, in Ireland</i> , pp. 22., large plate, containing coloured map and section - - - [v. 11.	2 6	3 6
119.	WEAVER, Thos., F. R. S. <i>On the Geological Relations of the South of Ireland</i> , pp. 68., large coloured map and large plate of coloured sections - [v. 1.	4 0	5 6

120. WEBSTER, THOS. *Observations on the Strata at Hastings, in Sussex*, pp. 6., plate of sections and plate of fossils - - - [ii. 3. 2 0 2 6]
121. ——— *Observations on the Purbeck and Portland Beds*, pp. 8., plate of fossils - - - [ii. 4. 2 0 2 6]
122. WETHERELL, N. T., F.G.S. *Observations on a Well dug on the South Side of Hampstead Heath*, pp. 6., and 2 plates of Organic Remains - - - [v. 8. 2 6 3 6]
123. WILLIAMS, REV. DAVID. *Notes on the Discovery of a Mass of Trap Rock in the Mountain Limestone of Bleadon Hill, in the County of Somerset*, pp. 2., one wood-cut - - - [vi. 35. 0 6 1 0]
 ——— *Letter on a Raised Beach near Barnstaple*. [v. 24. See 101.]
124. WILLIAMSON, W. C. *On the Distribution of Fossil Remains on the Yorkshire Coast, from the Lower Lias to the Bath Oolite inclusive*, pp. 20. - [v. 19. 2 6 3 6]
125. ——— *On the Distribution of Organic Remains in the Strata of the Yorkshire Coast, from the Upper Sandstone to the Oxford Clay inclusive*, pp. 10. [vi. 9. 1 6 2 0]
126. WRIGHT, ROMLEY. *Notes on the Geology of the Brown Clee Hill, in the County of Salop*, pp. 2., plate containing coloured map and sections - - - [v. 6. 1 0 1 6]
127. YATES, REV. JAS., M.A. *Observations on the Structure of the Border Country of Salop and North Wales, and of some detached Groups of Transition Rocks in the Midland Counties*, pp. 28., coloured map and plate - - - [ii. 15. 2 0 2 6]

THE
QUARTERLY JOURNAL
OF
THE GEOLOGICAL SOCIETY OF LONDON.

I. INTRODUCTORY NOTICE.

Apartment of the Geological Society of London,
Somerset House, Jan. 22d 1845.

At the Anniversary Meeting of the Geological Society, held in February 1844, the Council announced in their Annual Report, that in consequence of the great influx of original papers, and the delay and expense attending the Quarto form of publication*, it was their intention to adopt in most instances one attended with more expedition, and more commensurate with the funds of the Society.

It is in furtherance of their intention so announced, that the present new Publication appears, intituled "The Quarterly Journal of the Geological Society of London."

* In order to obviate misconception, the Council beg it to be understood that the present Journal will not supersede the continuation of the quarto form of publication in cases that be judged to require it.

It is the result of an agreement entered into between the Geological Society and the Publisher, and will be edited by one of the officers of the Society, its Vice-Secretary, subject to the superintendence and control of the Council.

The Journal will consist of two parts. The first will be a full Report of the original Communications read before the Meetings of the Society, the Authors being, as heretofore, held responsible for the facts and opinions stated in their respective papers: these Reports will be accompanied with figured illustrations.

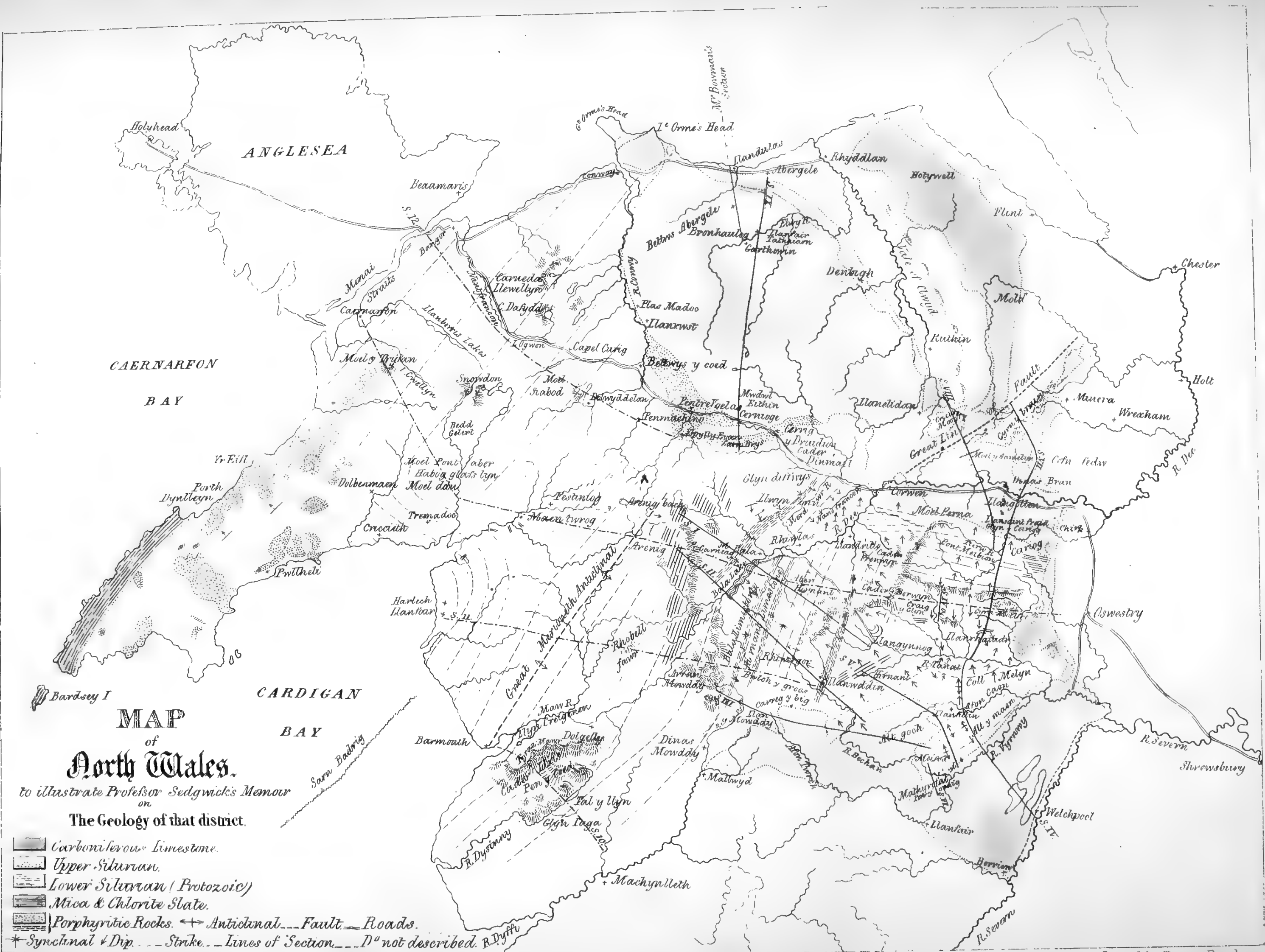
The second, or miscellaneous part, will consist of Translations or Abstracts of Geological papers published in the Transactions of Foreign Societies or in foreign Journals, and of analyses of the contents of works expressly Geological, both English and Foreign; but the Articles in this division of the Journal will also extend to such publications in the departments of Natural Philosophy, Chemistry, and Natural History as may be judged to have a more immediate bearing on Geology, strictly so called.

This second part will also contain announcements of Geological discoveries, of the publication of new Geological works, and other information of a mixed character, on Geological subjects. The articles in this second part, also, will, if necessary, be illustrated by figures.

The account that will be given of Geological publications will be confined to an analysis of their contents, and will not express any opinion on the general merits of the works analyzed. If any omission or inaccuracy on the part of an

Author should be noticed, such notice will be strictly limited to the particular matter adverted to, and will be expressed in guarded and courteous terms.

The First Number appears on the 1st of February, 1845, and the other numbers of the present year will be published on the 1st of the months of May, August, and November; and these will be followed, if due encouragement be given to this publication, by quarterly numbers appearing at corresponding periods, extending, it is hoped, for a long series of years.



MAP
of
North Wales.
to illustrate Professor Sedgwick's Memoir
on
The Geology of that district.

Carboniferous Limestone.
Upper Silurian.
Lower Silurian (Protozoic).
Mica & Chlorite Slate.
Porphyritic Rocks. \leftrightarrow Anticlinal --- Fault --- Roads.
* Synclinal ∇ Dip. --- Strike. --- Lines of Section. --- D° not described. R. Dyff.



II. PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

NOVEMBER 29. 1843.

Joseph Travis Clay, Esq., and Francis W. Jennings, Esq., were elected Fellows of this Society.

The following communication, a part of which had been read at the previous meeting, was concluded : —

On the OLDER PALÆOZOIC (Protozoic) ROCKS OF NORTH WALES.

By the REV. A. SEDGWICK, M.A., F.R.S., Woodwardian Professor of Geology and Fellow of Trinity College in the University of Cambridge.

§ 1. *Introduction.*

IN a paper read before the Geological Society in June, 1843, and intituled, “An Outline of the Geological Structure of North Wales,”* the author gave a description of those stratified rocks in the northern counties of the principality which are of anterior date to the mountain limestone. Those rocks he separated into the following three principal groups : —

1. Chlorite-slate and mica-slate. These form a band along the north-western side of the promontory of Carnarvonshire from Porth Dilley to Bardsea island.

2. Greywacke and roofing slate, often containing calcareous bands, and alternating with Plutonic rocks of cotemporaneous formation : and these rocks the author terms, in his present paper, the *Protozoic*, group. They extend in an east and west direction, from the borders of Shropshire to the western coast of Carnarvonshire ; and their north-western boundary, from the confines of Shropshire to Yspsyty Evan, coincides nearly with the Holyhead road ; and from Yspsyty Evan to Conway, with the Conway river.

3. An overlying and sometimes unconformable deposit of flag-

* Proceedings of the Geological Society of London, vol. iv. p. 212.

stone, &c., coterminous along the Holyhead road and Conway river with the last-mentioned principal group; but bounded towards the north-west by an overlying range of mountain limestone.

The present paper communicates the results of new researches which, in the company and with the assistance of his friend, Mr. J. W. Salter, the author made, during the summer of 1843, in the eastern portion of his former field of observation: his remarks on the present occasion being directed principally to the geological position and organic remains of the fossiliferous slates which lie to the east of the great Porphyry range of the Arenigs.

During these excursions, besides correcting the north-western boundary line of the rocks belonging to the second principal group, the author determined their southern boundary. That boundary follows a very sinuous course from the mountain limestone of Llanymynech hill, on the east, to the Dyfi near Mallwydd, on the west; whence it runs in a south-western direction, down the right or northern bank of that river for several miles. The boundary line of the protozoic rocks, both in the north and in the south, was laid down by the author and his companion on the Ordnance Map, from which they have been transferred to the small map annexed to the present Abstract.

The author has also materially improved the details of the sections which he formerly exhibited to the Society, and has greatly extended his lists of fossils. For the determining of these fossils, for the lists of them appended to this abstract, and for the general observations* which an examination of these lists has given rise to, he expresses himself indebted to Messrs. J. C. Sowerby and J. W. Salter, of whom the latter examined most of the localities where the fossils were obtained.

§ 2. *On the Calcareous Slates and Limestone of Glyn Dyffws on the Holyhead road, West of Corwen and of Rhiwlas, North East of Bala.*

In an endeavour to determine the position of the limestone of Glyn Dyffws, a series of calcareous and fossiliferous slates was traced from Cader Dinmael, on the north, through Glyn Dyffws and Pen-y-Cerrig, southward, to the hills on the left bank of the Merddwr brook, near Llwyn Onn. Here the strike was interrupted by enormous dislocations.

Calcareous slates, passing into limestone, again appear, to the south and west, at Llwyn Jolyn, Craigian-buchan-isaf, Llwyn-y-ci, and again, on the same line of strike, in the high grounds of the Rhiwlas estate N.E. of Bala, and lastly, about a mile above Bala, in the bed of the river Tryweryn. A part of this limestone band has been noticed by Mr. Sharpe.†

* In this Abstract the observations of Messrs. Sowerby and Salter are annexed to Professor Sedgwick's description of the geological position of the fossils; and, for distinction's sake, are printed in smaller type.

† Proceedings of the Geological Society, vol. iv. p. 10.

The above calcareous rocks, which may be termed those of Glyn Dyffws and Rhiwlas, might be supposed, from their proximity and almost uniform strike, to belong to one deposit; but no proof of such a connection is obtained by the evidence of sections, the interval between the above two series of localities being much disturbed and broken. Moreover, the fossils of the Rhiwlas beds, considered as a whole, appear to differ from those of Glyn Dyffws, which agree with those of the limestone band, known by the name of the "Bala limestone," on the eastern side of the lake. It is clear that the Rhiwlas limestone lies far below that of Bala; for the strike of the former passes a mile to the west of the western shore of the lake; and in that line of strike calcareous beds are found, though not in the form of limestone, agreeing, in respect of their organic remains, with the Rhiwlas series.

The fossils of Glyn Dyffws and Rhiwlas will be treated of in describing the first line of section.

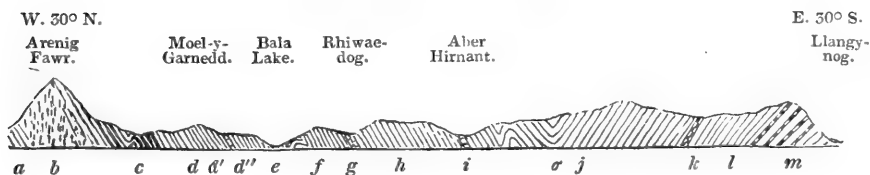
Fossiliferous bands, which occasionally pass into limestone, are also found at several places a little to the north-west of the localities which afford the Rhiwlas limestone. Those places are, 1. the valley above Pentre Cwmda; 2. a spot east of the mountain road between Garw fynydd and Moel Emoel; and 3. Eglws Anne in the forks of the Nant-y-Coegnant. Unless there be an inversion of the beds in all that district (and of such an inversion the author could perceive no indications) these last-mentioned calcareous bands must lie considerably below the Rhiwlas limestone.*

§ 3. *Transverse Sections across the Southern End of the Berwyn Chain.*†

SECTION I.

ARENIG FAWR to the TANAT RIVER at LLANGYNOG.

Horizontal base 15 miles.



* At a still lower level, apparently, lie the non-fossiliferous bands of limestone, which occur at the following places: —

1. To the S. W. of Arenig Fawr, in the upper branches of the Lliw.
2. Near Hengwrt Uchaf, on the road from Dolgelly to Bala; the limestone forming three bands, which were at one time worked for lime.
3. On the east flank of Cader Idris.
4. On the road from Dolgelly to Dinas Mowddu.

These non-fossiliferous bands are all crystalline; and appear to have been much altered by igneous rocks.

† The lines of section, with their numbers attached, are laid down on the Map, which accompanies this Abstract.

1. Immediately to the west of Arenig Fawr slates occur (*a*), dipping eastward. They contain *Asaphus Buchii*, and a few other fossils.

2. Next occur the Porphyries of Arenig (*b*), which are regarded by the author as old eruptive or recomposed trappean rocks, of cotemporaneous date with the slates with which they are associated. They form, therefore, no determinate base for the protozoic rocks of North Wales.

3. Upon the Porphyries rests a thick deposit of dark earthy slates (*c*) dipping eastward, and extending in that direction about a mile. Towards the upper limit of this bed numerous fossils occur; viz. *Asaphus Powisii*, *Trinucleus Caractaci*, *Leptæna sericea*, Encrinital stems, &c.

4. Immediately over the preceding is a still thicker bed of grey slate (*d*, *d'*, *d''*), which, including the very fossiliferous band, *d'*, supposed to be the equivalent of the Rhiwlas limestone, extends to the western shore of Bala lake. Measured in a direction transverse to the strike, the horizontal distance to the lake exceeds two miles; and as the dip, with one very limited exception, is steadily towards the east, and at a very considerable angle, the thickness of this bed must be great. The whole of the bed is fossiliferous. Near Moel-y-Garnedd were found an *Asterias*, *Orthis flabellulum*, Encrinital stems, &c. Further eastward are the very fossiliferous slates, the supposed equivalent of the Rhiwlas limestone; and close to the margin of the lake, still higher, fossil bands appear.

The total thickness of these fossiliferous beds west of Bala lake, without including the masses of interbedded Porphyry, is estimated by the author at not less than 2000 feet.

[The series of the Rhiwlas limestone, and of the fossiliferous beds west of Bala lake, is characterised by an abundance of Orthoceratites, and by *Asaphus Buchii*, *Illænus Bowmanni* (a new species), and other Trilobites. To these add *Asterias primæva*. Notwithstanding the considerable number of species of Brachiopoda contained in the list of fossils of the Protozoic rocks of North Wales (*vide* List I.), the number of such remains in the Rhiwlas series is very small.]

4. The breadth of the lake is supposed to be occupied by a group of hard quartzose slates (*e*); since further to the south such slates are seen to rest on the beds associated with the Rhiwlas limestone. Their thickness is not less than six or seven hundred feet.

5. The first group on the east side of the lake consists of a series of hard grey slates (*f*), which contain some highly fossiliferous bands. Some of these are much contorted on the line of strike; but their aggregate thickness is computed at not less than 500 feet.

6. Next occurs the Bala limestone (*g*), a complex group about 100 feet thick, containing two bands of impure limestone, one only of which, about 12 feet thick, is worked for lime. In one place it contains a bed of schaalstein.

[The Bala limestone and the Glyn Dyffws beds are marked by multitudes of Orthides, particularly *O. Actoniæ* and *O. Vespertilio*, besides *Leptæna tenuistriata*, and, in some places, an abundance of *Asaphus tyrannus* and *A. Powisii*. They contain few species of coral, but specimens are very abundant, and these belong

principally to the genus *Favosites*. (The *Chatetes petropolitana* is also very common.) The *Ophiura Salteri* has been found both in the Bala limestone and at Cader Dinmael. The series, moreover, furnishes two or three species of *Cypricardia*, a genus not previously found in Lower Silurian rocks.]

7. Next comes a series of slates (*h*), of very varied colour and texture, which alternate with bands of greywacke. As these beds dip steadily towards the east at a very high angle, and are more than a mile broad, their thickness must be very great.

8. The Hirnant limestone (*i*) follows, and has a remarkable pisolitic structure; but, as a limestone, it is very impure. This group is of considerable thickness. The beds are highly inclined, and dip to the east, a few degrees south. The group was traced by the author from Aber Hirnant southwards, in the direction of the strike, to Bwlch-y-Groes*, and was laid down on the Ordnance Map.

[The Hirnant limestone is characterised by its containing only a few species of *Orthis*; in which respect it differs in a remarkable degree from the limestone of Bala. Of those which it does contain, two or three (which are new species†, and very flat) are found in great abundance. It abounds in a new plaited *Terebratula*, and in *Encrinital* stems; but contains only a few corals].

9. With the same easterly dip, and at a high angle of elevation, follows a very thick group of slate rocks (*j*). Some are dark and earthy, others grey and siliceous, others glassy and chloritic. They alternate with a few bands of cotemporaneous Porphyry.

[Over the preceding, near the synclinal of the South Berwyns, fossils, resembling those of the Bala limestone, appear here and there, but in no great abundance; and the peculiar species of the Hirnant limestone are lost. These beds seem to possess scarcely any *Conchifera* or *Gasteropoda*, and not any *Orthoceratites*. The fossils belong principally to *Brachiopoda*, and *Leptæna sericea* is abundant, but so also is *Trinucleus Caractaci*. Some of the sandy beds contain *Encrinital* stems, but corals are very rare.]

10. More than a mile to the east of the Hirnant limestone is a synclinal line (*σ*), beyond which the beds dip towards the west. The lower beds, which were found to the westward, are therefore again brought to the surface, and the Bala limestone (*k*) reappears in two places near the top of the descent leading to Llangynog. Both these places are on the eastern side of the watershed of the

* It has been stated by Mr. Sharpe, in a paper read before the Geological Society (see "Proceedings of the Geological Society," vol. iv. p. 13.), that the line of the Bala limestone, as laid down in Mr. Murchison's map of the Silurian formations, is composed of the Bala and the Hirnant limestones. The Bala limestone, along its whole line of strike, and its several quarries, were examined by Professor Sedgwick in the year 1832; and were laid down by him in colours on Evans's half-inch map of North Wales. The Hirnant limestone was seen by him in the same year, and recognised as a distinct bed. He supposed it to be continued to the east side of Bwlch-y-Groes, but did not mark its course upon any map. Mr. Murchison, in representing the course of the Bala limestone, merely transferred Professor Sedgwick's coloured representation to his own map; and in this transfer from a map in which the physical features of a country are very ill represented, to another map in which they are well represented, it is possible that some errors may have been committed. But for these errors Professor Sedgwick states that he is not responsible.

† Some of these resemble the new species which were found at Cyn-y-brain, N. of Llangollen.

Berwyns; and, consequently, on this line of traverse, the Bala limestone dips under the Berwyns, as Mr. Murchison* has correctly stated. Further northwards that is not the case.

[The series of fossils on the line from Llanwddyn to the head of the Pennant valley, and thence to the top of the pass west of Langynog, is the exact counterpart of the list from the limestones of Bala and Glyn Dyffws.]

11. The limestone is followed in descending order, 1st. by fossiliferous slates (*l*); 2dly, by slates without fossils alternating with beds of Porphyry (*m*). These are supposed to represent a part of the series between the Bala limestone and Arenig at the western end of the section; and they are cut off, near Llangynog, by a complicated series of faults. The author here takes occasion to remark on the very great aggregate thickness of the fossiliferous beds which are traversed by the line of section just described; although, on the one hand, the section has no determinate base, and, on the other, does not reach to the highest of the protozoic rocks; since it is impossible to tell how many hundred feet may be wanting to connect the highest beds which are traversed in this section, with the base of the Denbighshire flagstones.

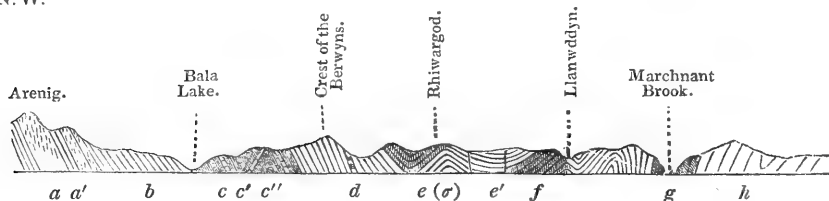
SECTION II.

The ARENIGS to LLANWDDYN.

Horizontal base 20 miles.

N.W.

S.E.



This section, like the former, commences on the west side of Bala lake, and with a ridge of porphyry (*a a'*); but the porphyry appears at a higher geological level than in the former section. The section passes through the grey slates (*b*) on the west side of the lake, and on the east side, through the Bala limestones (*c c' c''*), which, on this line, are very much contorted. It then traverses the strike of the Hirnant limestone (*d*), and exhibits in great perfection the beds (*e*), above that limestone. The synclinal axis (σ) lies here considerably to the east of the mountain crest; and, to the west of that axis, the same beds are again repeated; but they are now much faulted and broken (*e'*). The beds (*f*), supposed to represent the Bala limestone, reappear in the hills near the village of Llanwddyn; from whence they may be followed northwards in the direction of their strike, through the head of the Pennant valley, and thence to the top of the pass

* See "Proceedings of the Geological Society," vol. iv. part i. p. 11.

between Llangynog and Bala, dipping westward beneath the chain of the southern Berwyns.

Below the village of Llanwddyn there continues a prevailing westerly dip; but the derangements are enormous, and, at the great bend in the Fyrnwy river, the lower Silurian rocks (*g*) are seen resting upon the upper (*h*) in a reversed position.

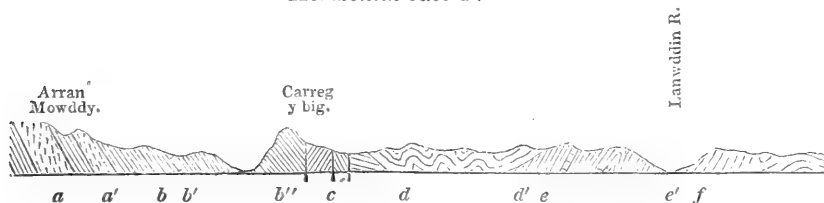
In this section, as in the former, the protozoic series is of great thickness.

SECTION III.

ARRAN MOWDDY TO LLANLIHANGEL.

Direction of the Section, W. 10° N. to E. 10° S.

Horizontal base 17 miles.



This section commences with cotemporaneous porphyries (*a a'*); but they break out at a still higher geological level than in Section II. The porphyry is succeeded by grey slates (*b b''*) containing the Bala series (*b'*), which may be followed southward in the direction of the strike, down the western bank of the Dyfi. The beds dip east by south, except to the extent of a faulted interval (*c*) on the east side of Carreg-y-big. We have in this line of section a great thickness of the fossiliferous portions of the protozoic series, but not the whole thickness; since these beds are succeeded in the line of section by a trough of overlying and unconformable Upper Silurian rocks, *dd'*. These rocks accord with the type, not of the Denbigh or Montgomery flagstones, but of the coarse-grained greywacké and flagstone which form the base of the upper system near Cernioge.

Beyond this trough, the older beds (*e e'*) again rise out, but with a reversed or northwesterly dip, and at a very high angle of inclination. At the east end of this, as of the former section, the Upper Silurians (*f*) pass under the Lower (*e*), owing to inversion.

In following the fossiliferous beds of the southern Berwyns to the neighbourhood of Mallwydd, the author found those beds overlaid by Upper Silurian rocks of the Cernioge type; a fact which had previously been noticed by Mr. Sharpe. Mr. Sharpe, however, considers that these Upper Silurians rest *conformably* on the Lower, and that the entire upper part of the Lower system is here displayed.* The author considers that the upper system wraps round the southern end of the Berwyns *unconformably*; and that the upper part of the lower system is incomplete.†

* Proceedings of the Geological Society, vol. iv. p. 13.

† The errors committed in certain parts of Mr. Murchison's map, in the neighbourhood of Mallwydd, by spreading the Cambrian colour over an area

§ 4. *On the Structure of the Berwyn Chain.*

1. This chain is considered as commencing, on the south, in the ridges above Mallwyd, to the east of the river Dyfi, and as stretching from thence in a north-westerly direction to the hills which overhang the Dee below Corwen.

2. If a line be drawn from the summit of the mountain pass between Llangynog and Bala to the great bend in the valley of the Dee between Llandrillo and Bala, the south-western portion of the chain, extending as far to the north-east as that line, constitutes a great trough. The subordinate groups of this southern portion of the chain are made up of the fossiliferous rocks of Bala; but its crests consist of beds far above the Bala limestone. On the eastern side of the trough the beds are partly vertical, and partly inverted; and on the south-eastern extremity of the chain, for several miles along the boundary between these disturbed rocks of the lower system and the co-terminous upper Silurians, the inversion affects also the upper system of rocks.*

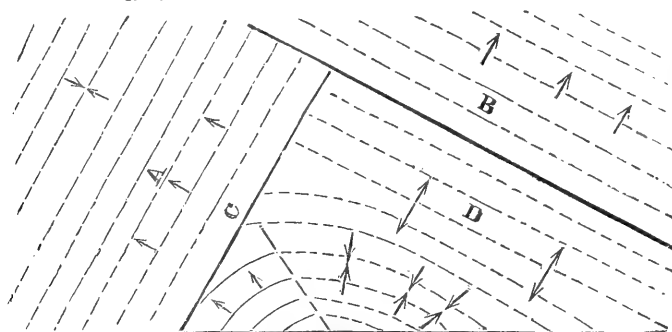
3. A longitudinal fault, with a great upcast to the west, ranges, on the eastern side of the chain, from the vertical and inverted beds above-mentioned to the northern end of Cader Ferwyn; in consequence of which, the Berwyn chain, for the distance of more than 4 miles north of the Llangynog pass, is no longer in a trough of rocks belonging to the Bala series; but the crest of the chain consists of rocks which are lower than the Bala limestone, but not lower than the fossiliferous slates on the east of Bala lake.

4. The strike of the higher ridges of the Berwyn chain varies from N. and S. to N. E. and S. W.; but N. N. E. and S. S. W. is about the mean strike.

which is actually covered by Upper Silurian rocks, has been pointed out by Mr. Sharpe. The same observation may be applied to a district extending along the south end of the Berwyns as far as the tributaries of the Severn. Professor Sedgwick observes, that since he had never either examined, or professed to have examined, this part of North Wales until the year 1843, he does not hold himself responsible for the colouring adopted in that part of the map in question.

* The following diagram has been prepared by the author, in illustration of his views respecting the structure of the North Berwyns.

Part of the Berwyns, N. of
Pass to Llangynog.



A. System of the North Berwyns.

B. Line of fault, North end of the Berwyns.

C. Line of fault, North Berwyns.

D. Llanrhiadr, anticlinal.

5. The beds, on the two opposite sides of the great upcast fault, are in a most anomalous position. On the west side, they strike about N. by E.; but on the east side, nearly E. and W.

6. At Bwlch Maengwynnedd, above a mile north of Cader Ferwyn, is another great fault or flexure. To the north of that point all the beds, to the further extremity of the chain, dip either N., or N. by E., and strike either E. and W., or E. by S., and W. by N. This strike is continued towards the east, as far as the mountain limestone on the confines of Shropshire; and, towards the west, to the hills north-west of Llandrillo, on the left bank of the Dee, between that river and the brook, Nant Ffrauan.

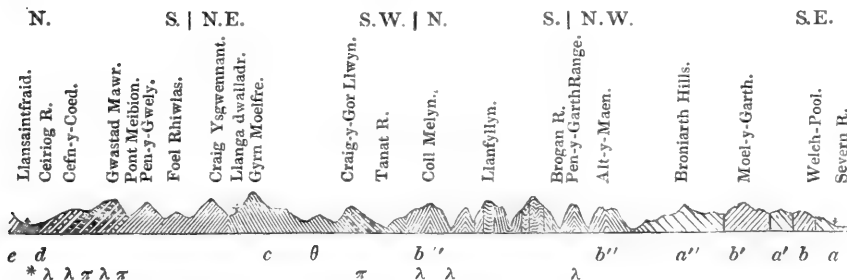
This position of the strata on the eastern side of the Berwyn chain gives a regular ascending section from the lower series to the upper, in advancing towards the Dee from south to north, along a meridian passing to the east of Llangynog.

§ 5. Sections East of the Berwyns.

SECTION IV.

WELCH-POOL on the SEVERN to LLANSAINTFRAID on the CEIRIOG.

Mean Direction of the line of Section, S. to N.
Horizontal base 24 miles.



1. At the southern extremity of Section IV., we have the Upper Silurian flagstone of the Severn (*a*), which formation, after two intervening portions of lower Silurian rocks (*b b'*), re-appears in the Broniarth hills (*a''*).

2. Then occurs a great undulating series of Caradoc sandstone (*b'', b'''*), with innumerable fossils; but among these the author discovered no trace of *Asaphus Buchii*, nor of some of the other characteristic species of the lower rocks in the Bala sections. These beds extend as far as the Tanat river, where the strike is nearly east and west.

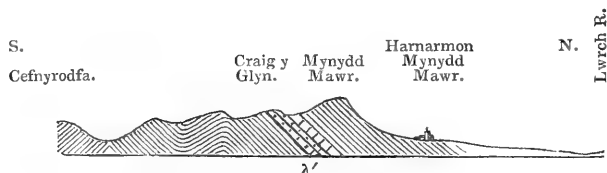
3. From beneath the Caradoc sandstone, there rises, north of the

* Those points where, either in the author's sections or coloured copy of the Ordnance Map, calcareous beds are marked as occurring, are denoted by the letter λ ; those points where porphyry is marked as occurring, are denoted by the letter π .

SECTION IV. a.

CRAIG-Y-GLYN, three miles and a half to the west of the line of Section IV. at the point marked θ .

Horizontal base $2\frac{1}{4}$ miles.



Tanat, a series of slates (θ), not differing in their mineralogical character from the slates of the higher Berwyns; and in these, at a great depth as measured from the Caradoc sandstone, are found calcareous bands, full of fossils, among which are *Asaphus Buchii*, &c. The Craig-y-Glyn limestone (*vide* Section IV. a.), which appears to the north of Llanrhaiadr, at the distance of nearly four miles to the west of the line of Section IV., the author regards as belonging to these bands.

[The Craig-y-Glyn limestone has most of the species of the Rhiwlas limestone; but the abundance of *Asaphus Buchii*, of *Orthis compressa*, of a new species of *Orthis*, and of *Encrinital* stems, give it a peculiar character.]

4. Still lower in the series are similar slates; but they are without fossils, and, after several breaks or undulations, the beds, about two miles further to the north, are found to have acquired a steady northern dip.

5. South of Pont Meibion, on the Ceiriog, fossils again appear, conforming to the types of the lower portion of the protozoic group.

[The lower part of the series near Pont Meibion may be only a repetition of the Craig-y-Glyn series, with a reversed dip. But the higher part of the series, which ranges over the crest of the Berwyns by Bwlch Llandrillo, contains only Bellerophons, particularly a new species, *B. nodosus*, found also at Soadley, in Shropshire, by Mr. Salter. At Bwlch Llandrillo, a new *Orthis*, *O. cambriensis*, which is also found in the Bala series, is abundant; and to this may be added many other species of *Orthis*, which that series contains.]

6. Then follows, in the ascending section, a great series of beds full of fossils, and these beds alternate with bands of cotemporaneous porphyry, schaalstein, &c.

7. Lastly, there is a well-defined thick group, whose width, measured transversely to the strike, is about a mile. It is composed of calcareous slates, and contains two bands of limestone, both of which have been worked for lime. It passes upwards into pale-coloured earthy slates (d), and these seem to pass, without a break, into the overlying Denbigh flagstone (e), which just appears on the southern bank of the Ceiriog, and extends northward from that river towards the vale of the Dee. The fossils both of paragraphs 5 and 6, are entered in the list of the Ceiriog fossils.

[The Llansaintfraid series, including the slates and two bands of limestone, lies above the porphyries of the Teirw river, and, consequently, far above the fossiliferous beds of Pont Meibion. It is distinct from any other part of the series, with the exception, perhaps, of the beds on the western bank of the Fyrnwy river, above Meifod. (*Vide* Section VI.) It is loaded with shells of the Wenlock limestone; among which are *Orthis sinuata* and *O. inflata*; *Spirifer crispus*, *Terebratula crispata*, *Atrypa affinis*, and *Euomphalus funatus*. It also contains nine or ten Wenlock corals, such as *Catenipora*, &c. Among the Orthides is a new species, which is found also at Coniston. Several of the corals belong to new species. Besides the above, are several well-known Caradoc sandstone species of shells.

In addition to the above positive characters, the group is distinguished by the following negative one — that it contains apparently none of the species which are characteristic of the lower parts of the Protozoic series, such as *Asaphus Buchii*, *Agnostus pisiformis*, *Ilænus Bowmanni*, *Spirifer crucialis*, &c.

This group, then, seems to form a kind of passage between the lower and upper systems.

To judge from the fossils only, the Coniston limestone appears to be intermediate between the Llansaintfraid and the Bala limestones.]

On the evidence of this Section and of the lists of fossils which belong to it, the author concludes :—

1. That the highest or Llansaintfraid group cannot be identified with any of the groups in Sections I., II., and III.; and that if it ever be brought into comparison with any group in those Sections, it must be with the highest group, namely, with that which is found near the crest of the southern Berwyns; and, therefore, that it lies far above the Bala limestone.

2. That the rocks from Pont Meibion southwards, and those of Craig-y-Glyn, may be brought into comparison with the lower parts of the Bala series, to the west of the lake, and with the slates east and west of Arenig, which contain *Asaphus Buchii*.

The preceding conclusions the author proposes, subject to the modifications which they must necessarily undergo, when his sections and lists of fossils come to be compared with those obtained by the gentlemen employed on the Ordnance Geological Survey, from an examination of the mountains of South Wales west of the district surveyed by Mr. Murchison.*

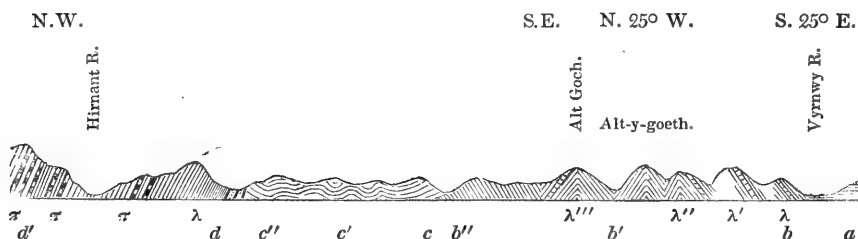
They exhibit no traces of the lower beds such as occur in North Wales, containing *Asaphus Buchii*, &c.; and they disappear when the Porphyries begin. The Coniston limestone appears to be very little lower than the limestones of the Ceiriog, and is therefore probably higher in the series than the Bala limestone. In North Wales, on the contrary, the fossiliferous series has no well-defined base, since fossiliferous beds of vast thickness, extending far below the Bala limestone, there alternate with porphyries.

* The sections of Cumberland and Westmoreland are not of a nature, in the author's opinion, to throw light on questions having reference to minute points in the classification of the different members of the Protozoic series of rocks. For, in those countries, the Lower Silurian rocks, containing fossils, are of comparatively small thickness, and have a well-defined base, which the author has formerly described. See "Proceedings of the Geol. Soc." vol. iii. p. 551.

SECTION V.

The VYRNWY RIVER, 1 mile S.W. of Meifod, to HIRNANT, about 2 miles S. of Llangynog.

Mean Direction of the line of Section, S. 40° E. to N. 40° W.
Horizontal base 10½ miles.

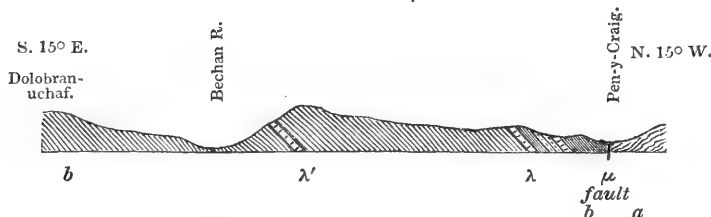


This section commences with the upper Silurian rocks (a), which extend southward from the Vyrnwy river to the Severn. It is followed by rocks of the lower series (b, b', b''), containing calcareous bands ($\lambda, \lambda', \lambda'', \lambda'''$). The lower fossiliferous bands near Meifod agree generally in their fossil species with the limestone of Bala, and with the fossiliferous beds on the line of the Teirw river occurring below, and associated with the porphyries, as described in Section IV. The line of section afterwards again cuts the overlying upper Silurian rocks (c, c', c''), a little within the line of their northern boundary. The lower system appears to the south of Llangynog, alternating with beds of cotemporaneous porphyry.

SECTION VI.

PEN-Y-CRAIG, 3 miles S.W. of Meifod, ACROSS THE BECHAN RIVER TO DOLOBRAN-UCHAF.

Horizontal base 1¾ miles.



At Pen-y-Craig, south of Mathyrafal, just at the base of the overlying upper Silurian flagstone (a), there is a higher fossiliferous group (μ) than any which has yet been described. The upper part of this passage group consists of calcareous shale, and the lower part of conglomerate, sandstone, and limestone. Further to the north we have the lower series of the ordinary type in the neighbourhood of Meifod, with two calcareous and fossiliferous bands.

[Note on the Fossils of the Limestone of Pen-y-Craig. — *Leptæna tenuistriata*, which was abundant in the lower fossiliferous group (λ), is not seen in the limestone. Corals are very abundant, and are nearly the same with those

of the upper limestone bands on the Ceiriog (*vide* Section IV.), but are very different from the corals of the lower group of the Meifod country. There are very great numbers of *Turbinolopsis bina*, of *Favosites polymorpha* and *F. alveolaris*, of *Cyathophyllum*, and *Stromatopora*.

On the Fossils of the *calcareous shale* of Pen-y-Craig. — In the very remarkable list of fossils (List I. column 13.) obtained from this shale, we have *Terebratula marginalis*, a Wenlock shell, associated with *Leptæna duplicata*, *Atrypa undata*, *A. globosa*, and *Orthis lata*, shells which have been considered as characteristic of the Llandeilo flags.]

From a review of all the preceding facts, the author concludes that the Protozoic series of North Wales is of enormous thickness; that it has no defined base, the fossils disappearing in the descending section, not suddenly, as in Cumberland and Westmoreland, but gradually; that many species are found in every subordinate group from the top to the bottom; and that some species, especially certain Trilobites, characterise the lower group.

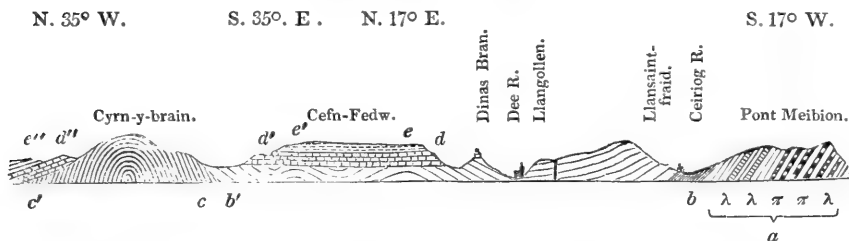
§ 6. Upper Silurian Rocks of Llangollen, Cernioge, &c.

The geological structure of this part of North Wales the author illustrates by three sections, which he exhibited to the Geological Society on a former occasion; but which, with the help of Mr. Salter, he is now able to present in a more accurate shape.

SECTION VII.

LLANSAINTFRAID, GLYN CEIRIOG, across the valley of the Dee, to CYRN-Y-BRAIN, near the head of the vale of the Clwyd.

Horizontal base 12 miles.



This Section may be considered as a continuation, northwards, of Section IV. To render clear the position of the upper Silurian flagstones of the Dee (*bb'*), lying as they do in a trough which is bounded, both to the north and to the south, by a mass of palæozoic rocks (*a* and *c c'*), a portion (*a*) of the older series of rocks, which lie to the south, and were before represented in Section IV., is here repeated. On the northern side of the trough, at Cern-y-brain, the existence of a mass of older rocks (*c c'*), which was before suspected by the author, has been ascertained; with the help of Mr. Salter, its extent has been laid down upon the Ordnance Map; and it has been inserted in the section.

In his paper, read before the Society in June, 1843, the author described the Upper Silurian Denbighshire Flagstone series as consisting of three subdivisions; which may be termed the Lower, the Middle, and the Upper Flags.

The lower flags consist of flagstone, passing into hard quartzose sandstone and earthy semi-indurated shale. Since it is only in the lower flags that an abundance has been found of Orthoceratites, and of the fossil found by Professor E. Forbes to be a Creseis, the name of 'Creseis flagstone' might serve as a good local name to give to this lower group. At nearly the base of the series, together with the Creseis, *Leptaena lata* has been found; but it is scarce. The uppermost portion of the lower flags (which has sometimes been described as non-fossiliferous) contains, though rarely, *Cardiola interrupta* and *Terebratula Wilsoni*.

The lowest upper Silurian rock exposed in this line of section is dark roofing slate, containing a few of the *Graptolites ludensis*. But this is a fossil which extends upwards, through the whole series of lower, middle, and upper flags.

All the upper Silurian rocks (*b*) upon this line of section, from the Ceiriog river to Castle Dinas Bran inclusive, are now considered by the author to belong to the lower flags. The character of the Llangollen fossils, taken as a whole (see list of them, Proc. Geol. Soc. vol. iv. p. 221.), and particularly the abundance they contain of *Terebratula navicula*, have led the author to come to this conclusion.*

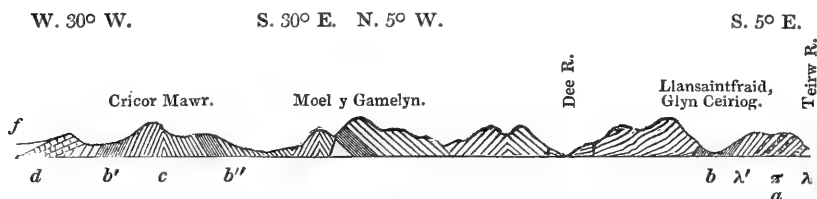
These upper Silurian rocks are overlaid by unconformable and nearly horizontal beds of mountain limestone (*d d'*); and these are crowned at Cefn Fedw by a capping of millstone grit (*e e'*). At the north-western base of Cefn Fedw, the upper Silurian rocks (*b'*) again appear, and are succeeded by the palæozoic mass of Cynr-y-Brain, full of Caradoc sandstone fossils. On the north-western flank of this mass the mountain limestone, crowned by millstone grit, again appears, and in an inclined position.

SECTION VIII.

The TEIRW RIVER, across the valley of the Dee, to CRICOR MAWR, near the head of the Vale of the Clwyd.

Mean direction of the line of section, S. 20° E. to N. 20° W.

Horizontal base 11½ miles.



This Section is nearly the counterpart of Section VII., and runs nearly parallel to it: it passes the Dee about 3 miles W. of Llangollen. At the southern extremity, on the Teirw river, we have the limestones ($\lambda \lambda'$), and porphyries of the Palæozoic series (*a*). Then follows a trough containing the dark roofing slate and the

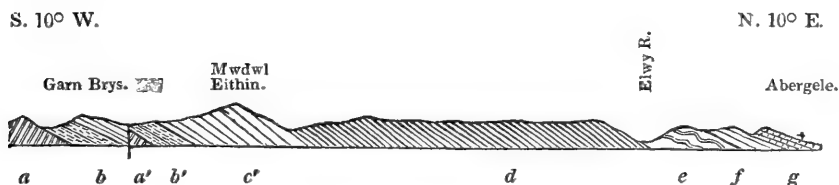
* In this view the author differs in opinion from the late Mr. Bowman, who separated this part of the upper series into subdivisions, which he compared with those of the entire Ludlow series of Mr. Murchison.

lower flags (*b b'*), of the upper Silurian series. Towards the northern extremity of the trough, a mass of the older rocks (*c*), abounding, like the similar mass of Cyn-y-brain, in fossils of the Caradoc sandstone, breaks out at Cricor Mawr. This mass is covered, on its north-western flank, by upper Silurian rocks; and these are overlaid by mountain limestone (*d*), a range of which bounding the vale of Clwydd on the S. E. runs from the point represented in the Section, beyond Abergele. The mountain limestone is followed by new red sandstone (*f*).

SECTION IX.

From GARN BRYs, S. W. of Cernioge, to ABERGELE.

Horizontal base 20 miles.



In this Section, we have, near Cernioge, first, the rocks of the older series (*a*), abounding with fossils of the Caradoc sandstone; and secondly, lying unconformably on the preceding, are the conglomerates and sandstones (*b*) which there constitute the base of the upper Silurian flagstones. These conglomerates, &c., the author compares to the coarse greywacké and flagstone which constitute the unconformable base of the upper series at the south-eastern extremity of the Berwyns. These coarse mechanical rocks do not appear in any distinct form in the country traversed by the two former lines of section. The conglomerates pass into sandstones of a finer structure, which alternate with bands of dark coarse slate having occasionally true slaty cleavage.

In this part of the Section, the author interpolates a fault, by overlooking which, he was led, when he first exhibited this Section, to estimate the conglomerates and sandstones at too great a thickness. To the north of this fault, the finer sandstones (*c'*) are repeated.

The lower sandstones have been already mentioned. The middle flags, the author formerly described as consisting of beds resembling those of the lower flags; but these beds are more indurated, and contain, here and there, many fossils. In this middle division he now proposes to include the coarse greywacké and slates of Bronhaulog (*e*); whereupon he takes occasion to remark that, in North Wales, slates arising from transverse cleavage extend to a higher geological level than they do in Westmoreland, and to a still higher level in Devonshire than they do in North Wales; and, consequently, that such cleavage does not define the age of any rock, but serves only, like other peculiarities of structure, to mark the existence of certain physical conditions.

The upper flags have been described by the author in his former paper as composed of softer beds than the lowest and middle subdivisions; those beds being more or less slaty, and containing few fossils. To this subdivision the author refers a bed, near the northern extremity of this Section, which contains *Graptolites ludensis*. Also at the end of the Section occurs a thick mass (*f*) in which are a number of beds like those of the lower groups, but often passing into rotten slate or *mudstone*. The last bed (*g*) in this Section is mountain limestone.

On the fossils of the lower, middle, and upper flags, as a whole, it may be remarked, that they agree very nearly with those from the upper Silurian rocks of Mr. Murchison; but that the distribution of species is somewhat different. Thus, in the list of fossils from the Lower Flags (*vide* list of fossils from Plas Madoc, Proc. Geol. Soc. vol. iv. p. 221.), species are found which were once supposed to be characteristic of the *tilestone* of Shropshire, a bed above the upper Ludlow mudstone. This may be accounted for by the circumstance, that both the tilestones and the Plas Madoc beds belong to an arenaceous deposit; and hence, though widely separated by intervening slates and flagstones, they have in common some species not found in the intermediate beds.

TABLE I.—**S. J. W. SALTER AND J. DE CARLE SOWERBY.**

The Columns are to be found in Column 4. [ED.]

NAMES OF GENERA	Sec. IV.	Ascending Order. See Sec. VI.		Extracted from the next List of Fossils.	OBSERVATIONS.
	12.	13.	14.	15.	
	Glyn-Ceiriog.	Pen-y-Craig Limestone.	Pen-y-Craig Calcareous Shale.	Of the foregoing Species the following are found also in the Upper Silurian rocks of N. Wales.	
<i>Crustacea</i>					
<i>Agnostus pisiformis</i>					
<i>Illænus Bowmani</i> (n. s.)					
<i>Paradoxides</i> (n. s.?)					
<i>Trinucleus Caractaci</i>	+				
<i>fimbriatus</i>	+				
<i>Asaphus Buchii</i>					
<i>tyrannus</i>	+				
<i>Powisii</i>					
<i>caudatus</i>				+	
(n. s.)					
<i>Calymene Blumenbachii</i>				+	
(n. s.)	+				
n. s. ? with					
<i>Entomostracites punctatus</i>			+		
<i>Mollusca. — Cephalopoda</i>					
<i>Nautilus primævus</i>	1				
<i>Lituities cornu arietis</i>	+				
<i>Phragmoceras</i> ? (n. s.)					
<i>Orthoceras</i> , smooth and					
smooth and					
smooth and	+				
<i>Heteropoda</i>					
<i>Bellerophon bilobatus</i>	+				
<i>nodosus</i>					
<i>Pteropoda</i>					
<i>Conularia quadrisulcata</i>					
<i>Gastropoda</i>					
<i>Pleurotomaria</i> (n. s. a)			+		
<i>Murchisonia</i> (de Ver)					
(n. s. ? la)	+				
<i>Turbo Pryceæ</i>					
<i>Littorina striatella</i>			+		
<i>Euomphalus funatus</i>	+				
(n. s.)	+				
<i>Conchifera</i>					
<i>Arca Eastnori</i> ?					
<i>Nucula</i> ? (n. s.)					
<i>Cypricardia</i> (n. s.)					
(n. s.)					
(n. s.)					
<i>Brachiopoda</i>					
<i>Lingula</i> (n. s. ?)			+		
<i>Terebratula decemplex</i>					
<i>tripartita</i>	+				
<i>crispata</i>	+				
<i>marginalis</i>		+	++		
(n. s.)					
(n. s.)					
(n. s.)		+	+		
<i>Atrypa affinis</i>	+	+	+	+	

Wenlock Limestone.

* The names made collection from Sweden, in the possession of Mr. Murchison.

TABLE I. — FOSSILS OF THE OLDER PALÆOZOIC (PROTOZOIC) ROCKS IN NORTH WALES. DRAWN UP BY MESSRS. J. W. SALTER AND J. DE CARLE SOWERBY.

NOTE. — Columns 1, 2, and 3, are added to this List on the authority of Professor Sedgwick's paper: other Fossils belonging to those Columns are to be found in Column 4. [Ed.]

NAMES OF GENERA AND SPECIES.	Localities taken in the Ascending Order. See Section I.								In the Descending Order, from Col. 8. See Sec. I.	In the Ascending Order. See Sec. IV.			Ascending Order. See Sec. VI.		Extracted from the next List of Fossils.	OBSERVATIONS.
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	
	Slates West of Arenig Fawr.	Dark earthy Slates E. of Arenig Fawr.	Gray Slates E. of Arenig Fawr.	Rhiwlas and Moel-y-Garnedd, W. of Bala Lake.	Cader-Dinmael and Glyn-Diffwys.	Rhiwaedog, E. of Bala Lake, to Bwlch-y-Groes, &c.	Aber Hirnant to Llan-Mowddy.	Pass to Llangynog and Rhiw-gwgor.	From Llangynog to Pennant and Llanwddyn.	Craig-y-Glyn.	Pont-y-Meibion to Bwlch Llan-drillo.	Glyn-Ceirlog.	Pen-y-Craig Limestone.	Pen-y-Craig Calcareous Shale.	Of the foregoing Species the following are found also in the Upper Silurian rocks of N. Wales.	
<i>Crustacea.</i>																
<i>Agnostus pisiformis</i> -	-	-	-	+	-	+	-	+	++	-	+	-	-	-	-	-
<i>Illæus Bowmani</i> (n. s.) -	-	-	-	+	-	-	-	-	++	-	-	-	-	-	-	-
<i>Paradoxides</i> (n. s. ?) -	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Trinucleus Caractaci</i> -	-	+	-	+	+	+	-	++?	+	+	+	+	-	-	-	-
<i>fimbriatus</i> -	-	-	-	-	+	-	-	+	+	-	-	+	-	-	-	-
<i>Asaphus Buchii</i> -	+	-	-	+	++?	-	-	-	-	+++	+	+	-	-	-	-
<i>tyrannus</i> -	-	-	-	+	+	+	-	-	+	+++	+	+	-	-	-	-
<i>Powisii</i> -	-	+	-	-	+	+	-	+	+	-	+	+	-	-	-	-
<i>caudatus</i> -	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-
(n. s.) -	-	-	-	-	-	+	-	-	+	+	+	+	-	-	+	-
<i>Calymene Blumenbachii</i> -	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-
(n. s.) -	-	-	-	-	+	+	-	+	-	-	-	+	-	-	+	-
n. s. ? with granulated head -	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Entomostracites punctatus</i> -	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
<i>Mollusca. — Cephalopoda.</i>																
<i>Nautilus primævus</i> -	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-
<i>Lituities cornu arietis</i> -	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
<i>Phragmoceras</i> ? (n. s. ?) -	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Orthoceras</i> , smooth and distant septa -	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-
smooth and close septa -	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
smooth and conical -	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
<i>Heteropoda.</i>																
<i>Bellerophon bilobatus</i> -	-	-	-	+	-	-	-	-	+	+	++	+	-	-	-	-
<i>nodosus</i> -	-	-	-	-	-	-	-	-	-	-	++	-	-	-	-	-
<i>Pteropoda.</i>																
<i>Conularia quadrisulcata</i> -	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Gasteropoda.</i>																
<i>Pleurotomaria</i> (n. s. angular) -	-	-	-	+	-	+	-	-	-	-	+	-	-	+	-	-
<i>Murchisonia</i> (de Vern.) -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(n. s. ? large) -	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
<i>Turbo Pryceæ</i> -	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Littorina striatella</i> -	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-
<i>Euomphalus funatus</i> -	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
(n. s.) -	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
<i>Conchifera.</i>																
<i>Arca Eastnori</i> ? -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Nucula</i> ? (n. s.) -	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
<i>Cypriocardia</i> (n. s.) -	-	-	-	+	+	+	+	-	++	-	-	-	-	-	-	-
(n. s.) -	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
(n. s.) -	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Brachiopoda.</i>																
<i>Lingula</i> (n. s. ?) -	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-
<i>Terebratula decemplicata</i> -	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
<i>tripartita</i> -	-	-	-	-	-	+	-	+	-	-	-	+	-	-	-	-
<i>crispata</i> -	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
<i>marginalis</i> * (imbricata) -	-	-	-	-	-	-	-	-	-	-	-	+	+	++	-	-
(n. s.) -	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-
(n. s.) -	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
(n. s.) -	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-
<i>Atrypa affinis</i> -	-	-	-	-	-	-	-	+	-	-	-	+	+	+	+	-

Wenlock Lime-
stone.

Wenlock Limestone.

* The names marked with an asterisk are names substituted for those given in the Silurian system, in consequence of the examination of a collection from Sweden, in the possession of Mr. Murchison.

TABLE I.—FOSSILS OF THE OLDER PALÆOZOIC (PROTOZOIC) ROCKS IN NORTH WALES—(continued).

NAMES OF GENERA AND SPECIES.	Localities taken in the Ascending Order. See Section I.								In the Descending Order, from Col. 8. See Sec. I.	In the Ascending Order. See Sec. IV.			Ascending Order. See Sec. VI.		Extracted from the next List of Fossils.	OBSERVATIONS.
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	
	Slates West of Arenig Fawr.	Dark earthy Slates E. of Arenig Fawr.	Gray Slates E. of Arenig Fawr.	Rhiwlas and Moel-y-Garnedd, W. of Bala Lake.	Cader-Dinmael and Glyn-Diffwus,	Rhiwaedog E. of Bala Lake, to Bwlch-y-Groes, &c.	Aber Hirnant to Llan-Mowddy.	Pass to Llangynog and Rhiwargor.	From Llangynog to Pennant and Llanwddyn.	Craig-y-Glyn.	Pont-y-Moibion to Bwlch Llandrillo.	Glyn-Ceiriog.	Pen-y-Craig Limestone.	Pen-y-Craig Calcareous Shale.	Of the foregoing Species the following are found also in the Upper Silurian rocks of N. Wales.	
<i>Atrypa undata</i> - -														+++		Llandillo Flags.
<i>globosa</i> - -												+		+		Llandillo Flags.
(3 new species) - -																
(2 or 3 new species) - -																
<i>Spirifer crucialis</i> - -				+	+	++		+	+							
<i>Cyrtæna*</i> (<i>radiatus</i>) - -				+		+						+				
<i>crispus</i> - -												+				
<i>Orthis elegantula*</i> (<i>canalis</i>) - -				+	+	+	+	+	+	+	+	+	+	+	+	
<i>testudinaria</i> - -				+	+	+	+	+	+	+	+	+	+	+	+	
<i>alternata</i> - -				+	+	+	+	+	+	+	+	+	+	+	+	
<i>Vespertilio</i> - -				+	+	+	+	+	+	+	+	+	+	+	+	
<i>Actoniæ</i> - -				+	+	+	+	+	+	+	+	+	+	+	+	
<i>flabellulum</i> - -			+	+	+	+	+	+	+	+	+	+	+	+	+	
<i>Cambriensis</i> (n. s.) - -				+	+	+	+	+	+	+	+	+	+	+	+	
<i>virgata</i> - -					+	+						+				
<i>compressa</i> - -										+++		+				
<i>sinuata</i> - -												++				
<i>inflata</i> (n. s.) - -																
<i>lata</i> - -												+				Llandillo Flags.
(2 new species) - -																
(n. s.) - -										++						
(n. s.) - -										+						
(3 new species) - -							+									
<i>Leptæna sericea</i> - -		+		+	+	+		++	+			+				
<i>tenuistriata</i> (<i>rugosa Dalm.</i>) - -					+	+		+	+			+				
<i>duplicata</i> - -												+			++	Llandillo Flags.
<i>transversalis</i> - -															++	
<i>depressa</i> - -													+		+	
(n. s.) - -					+	+			+							
(n. s.) - -				+								+			+	
(n. s.) - -												+				
(n. s.) - -																
<i>Orbicula</i> (n. s. large) - -						+										
<i>Radiaria.</i>																
<i>Ophiura Salteri</i> - -					+	+										
<i>Asterias primæva</i> - -			+			+			+	++		+			+	
<i>Eocrinus</i> (stems) - -		+	+	+++		+	+	+	+							
(pelvis) - -				+						+						
<i>Pentacrinites?</i> - -																
<i>Polyparia.</i>																
<i>Stromatopora</i> (n. s.) - -												++	++			
<i>Retepora</i> (with large meshes) - -												+				
(n. s.) - -												++				
<i>Fenestella?</i> (branched) - -												+			+	
(n. s.) - -												+	++		++	
<i>Turbinolopsis bina</i> - -												+				
(n. s.?) - -												+				
<i>Cyathophyllum dianthus</i> - -												+	++		+	
(n. s.) - -												++			++	
<i>Porites pyriformis</i> - -												++			++	
<i>Catenipora escharoides</i> - -								+	+		+					
<i>Chætetes petropolitana</i> - -					+	+					+	++				
<i>Favosites polymorpha</i> - -					+	+	?	+			+	++			++	
<i>spongites</i> - -											+	++			++	
<i>alveolaris</i> - -											+	++			++	
<i>Verticillipora abnormis?</i> - -					+						+	+				
<i>Tentaculites ornatus</i> - -											+					
<i>scalaris</i> - -																
<i>annulatus</i> - -					+	+							+		+	
Many undescribed - -																

IN NORTH WALES — (*continued*).

in the Ascending Order. See Sec. IV.			Ascending Order. See Sec. VI.		Extracted from the next List of Fossils.	OBSERVATIONS.
10.	11.	12.	13.	14.	15.	
raig-y-Glyn.	Pont-y-Moebion to Bwlch Llandrillo.	Glyn-Ceiriog.	Pen-y-Craig Limestone.	Pen-y-Craig Calcareous Shale.	Of the foregoing Species the following are found also in the Upper Silurian rocks of N. Wales.	
A				+		Llandillo Flags. Llandillo Flags.
				+		
S				+		
C						Llandillo Flags.
+	+	+	+	+		
+	+	+	+	+		
+	+	+		+		
	+	+				
	+	+				
	+	+				
+	+	+				
+	+	+				
+	+	+				
+	+	+				Llandillo Flags.
+	+	+				
+	+	+				
+	+	+				
+	+	+				
+	+	+				
+	+	+				
+	+	+				
+	+	+				
+	+	+				
+	+	+				Llandillo Flags.
+	+	+				
+	+	+				
+	+	+				
+	+	+				
+	+	+				
+	+	+				
+	+	+				
+	+	+				
+	+	+				
+	+	+				Llandillo Flags.
+	+	+				
+	+	+				
+	+	+				
+	+	+				
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+	+	+				
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+	+	+				
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+	+	+				Llandillo Flags.
+	+	+				
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+	+	+				
+	+	+				Llandillo Flags.
+	+	+				
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+	+	+				Llandillo Flags.
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+	+	+				Llandillo Flags.
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+	+	+				Llandillo Flags.
+	+	+				
+	+	+				
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TABLE II.

Fossils of the Denbigh Flagstone and Sandstone Series, found in various Parts of North Wales.

[Drawn up by MESSRS. J. W. SALTER and J. DE CARLE SOWERBY.]

<p><i>Crustacea.</i> <i>Calymene Blumenbachii.</i> <i>Downingia.</i> one or two new species. <i>Asaphus caudatus.</i> <i>longicaudatus.</i> <i>Cawdori.</i> <i>(subcaudatus).</i></p> <p><i>Annelida.</i> <i>Serpulites longissimus.</i></p> <p><i>Cephalopoda.</i> <i>Lituites Ibex.</i> <i>Orthoceras striatum.</i> <i>articulatum.</i> <i>virgatum.</i> <i>annulatum.</i> * <i>Creseis tenue</i> † (<i>Vahl</i>). <i>(primæva).</i> * a conical species.</p> <p><i>Heteropoda.</i> <i>Bellerophon carinatus.</i> <i>globatus.</i> <i>trilobatus.</i> n. s.</p> <p><i>Gasteropoda</i> <i>Turritella obsoleta.</i> <i>conica.</i> <i>Natica parva.</i> <i>Trochus helicites.</i></p> <p><i>Conchifera.</i> * <i>Avicula</i> (fragments). <i>Nucula.</i> <i>Cucullæa antiqua.</i> a large n. s.</p>	<p>* <i>Cardiola interrupta.</i> * <i>Cardium</i> ? <i>Cypricardia</i> (several imperfect).</p> <p><i>Brachiopoda.</i> <i>Terebratula navicula.</i> † <i>semisulcata.</i> <i>(lacunosa. Sil. Sys. p.5.)</i> <i>Nucula.</i> <i>Wilsoni.</i> <i>bidentata.</i> <i>Orthis lunata.</i> <i>orbicularis.</i> two or three new species. <i>Spirifer ptychodes.</i> <i>interlineatus.</i> <i>Atrypa affinis.</i> two or three new species. <i>Leptæna lata.</i> † <i>euglypha.</i> <i>depressa.</i> <i>Orbicula rugata</i> ?</p> <p><i>Radiata.</i> Crinoidal remains abundant. * <i>Actinocrinites</i> (n. s. highly ornamented. — <i>Llangollen</i>).</p> <p><i>Polyparia.</i> <i>Stromatopora.</i> <i>Fenestella.</i> <i>Cyathophyllum</i> (several species). <i>Favosites</i> (several species, one very slender). * <i>Graptolites ludensis.</i></p>
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* Denotes the species characteristic of the Denbigh flagstone series.

† Names substituted for those given in the Silurian system, in consequence of the examination of a collection from Sweden, in the possession of Mr. Murchison.

‡ Denotes the species which have hitherto been found only in the more calcareous beds at Plas Madoc, Llanrwst.

TABLE III.

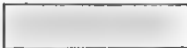




TABULAR VIEW of the PROTOZOIC ROCKS OF NORTH WALES, in the ascending Order.

West of the Berwyns.	Chlorite Slate. (From <i>Porth Dinlleyn</i> to <i>Bardsea Island</i> , in the <i>S. W.</i> of <i>Carnarvonshire</i> .)	Slate and porphyries. (No fossils yet discovered.)	Slate and porphyry with crystalline limestone and a few fossils, e.g. <i>Asaphus Buchii</i> . (<i>W. of Arenig Fawr</i> .)	Porphyries, with a few bands of slate. (<i>Arenig Fawr</i> .)	Slate with bands of limestone, and many fossils: <i>Asaphus Buchii</i> . (<i>Rhiwlas, &c.</i>)	Slate, with a few trap bands, and a band of limestone, a calcareous slate. (<i>Glyn Dyffwrds east side of Bala Lake</i> .)	Slate, and band of limestone. (<i>Hirnant river</i> .)	Slates, with a few fossils. (<i>Crest of the Southern Berwyns, and east of the Crest</i> .)	Coarse sandstone, with a band of limestone and calcareous shale. (<i>Pen-y-Craig, S. W. of Meifod</i> .)	Upper Silurian.
			Soft earthy slates.	Soft earthy slates, with arenaceous bands, and a thick mass of calcareous slate. (<i>Craig-y-Glyn</i> .)	Coarse sandstones and earthy slates; the lower part with the fossils of the <i>Bala limestone</i> . (<i>Tyrnwy R., above Meifod</i> .)	Coarse slate and porphyries. (<i>Teirw River, falling into the Ceiriog</i> .)	Calcareous slates, with bands of limestone. (<i>Glyn Ceiriog</i> .)			Upper Silurian.
East side of the South Berwyns.			Soft earthy slates.	Soft earthy slates, with arenaceous bands, and a thick mass of calcareous slate. (<i>Craig-y-Glyn</i> .)	Coarse sandstones and earthy slates; the lower part with the fossils of the <i>Bala limestone</i> . (<i>Tyrnwy R., above Meifod</i> .)	Coarse slate and porphyries. (<i>Teirw River, falling into the Ceiriog</i> .)	Calcareous slates, with bands of limestone. (<i>Glyn Ceiriog</i> .)			Upper Silurian.
			Soft earthy slates.	Soft earthy slates, with arenaceous bands, and a thick mass of calcareous slate. (<i>Craig-y-Glyn</i> .)	Coarse sandstones and earthy slates; the lower part with the fossils of the <i>Bala limestone</i> . (<i>Tyrnwy R., above Meifod</i> .)	Coarse slate and porphyries. (<i>Teirw River, falling into the Ceiriog</i> .)	Calcareous slates, with bands of limestone. (<i>Glyn Ceiriog</i> .)			Upper Silurian.
East side of the North Berwyns.			Soft earthy slates.	Soft earthy slates, with arenaceous bands, and a thick mass of calcareous slate. (<i>Craig-y-Glyn</i> .)	Coarse sandstones and earthy slates; the lower part with the fossils of the <i>Bala limestone</i> . (<i>Tyrnwy R., above Meifod</i> .)	Coarse slate and porphyries. (<i>Teirw River, falling into the Ceiriog</i> .)	Calcareous slates, with bands of limestone. (<i>Glyn Ceiriog</i> .)			Upper Silurian.
			Soft earthy slates.	Soft earthy slates, with arenaceous bands, and a thick mass of calcareous slate. (<i>Craig-y-Glyn</i> .)	Coarse sandstones and earthy slates; the lower part with the fossils of the <i>Bala limestone</i> . (<i>Tyrnwy R., above Meifod</i> .)	Coarse slate and porphyries. (<i>Teirw River, falling into the Ceiriog</i> .)	Calcareous slates, with bands of limestone. (<i>Glyn Ceiriog</i> .)			Upper Silurian.

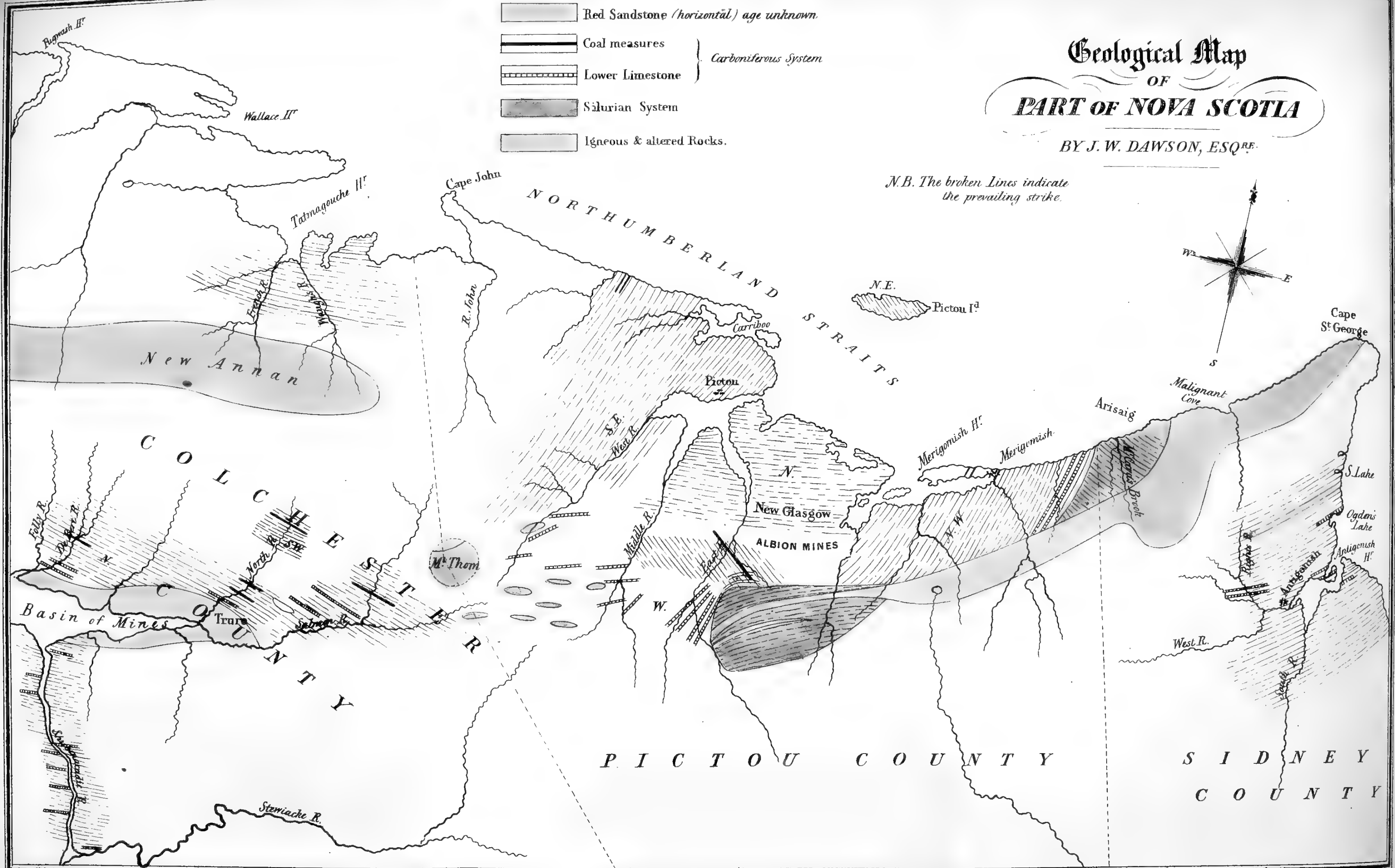
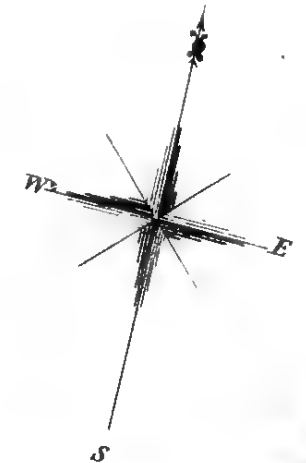


Geological Map OF PART OF NOVA SCOTIA

BY J. W. DAWSON, ESQ.^{RE.}

-  Red Sandstone (*horizontal*) age unknown.
 -  Coal measures
 -  Lower Limestone
 -  Salurian System
 -  Igneous & altered Rocks.
- } Carboniferous System

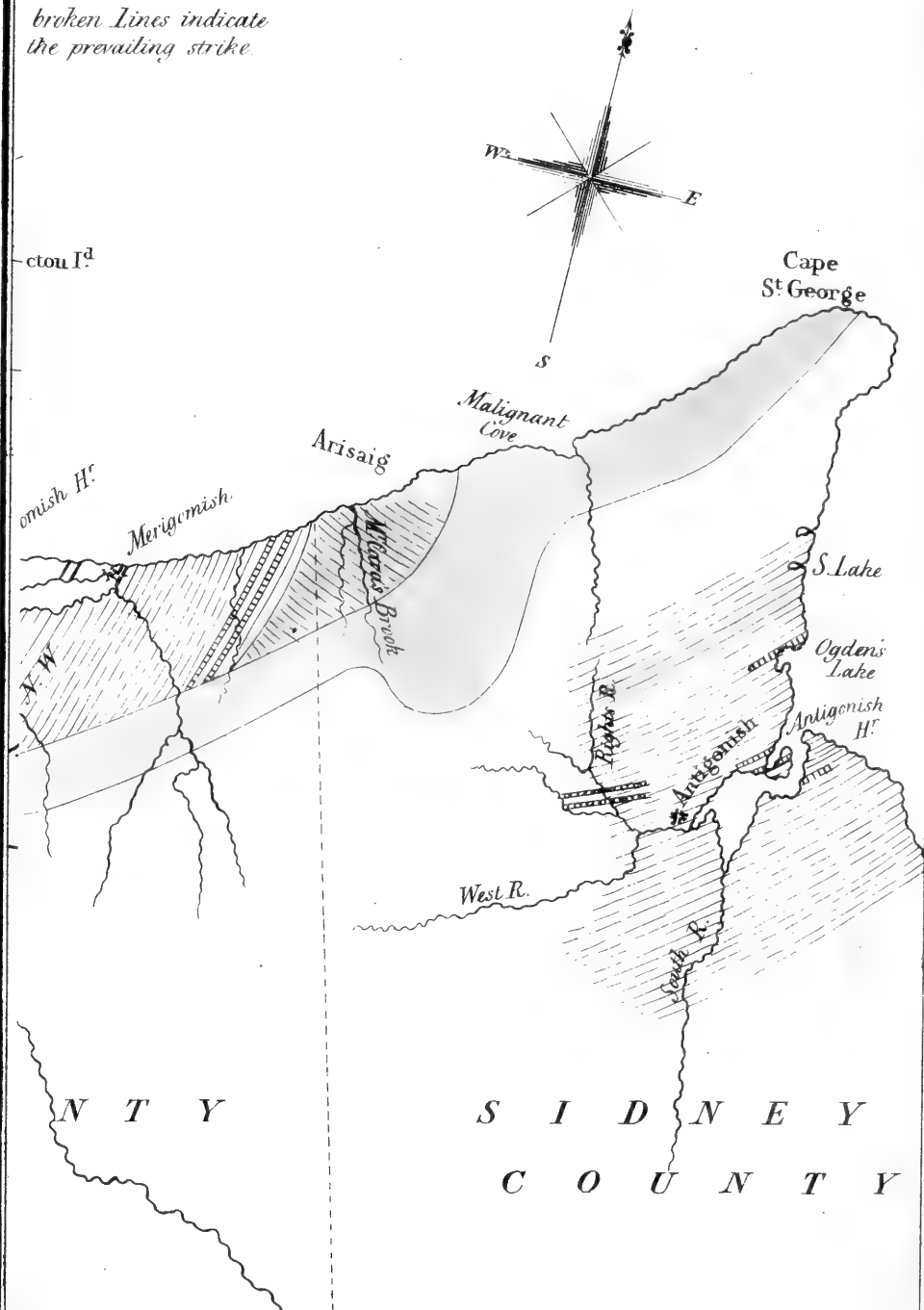
N.B. The broken Lines indicate
the prevailing strike.

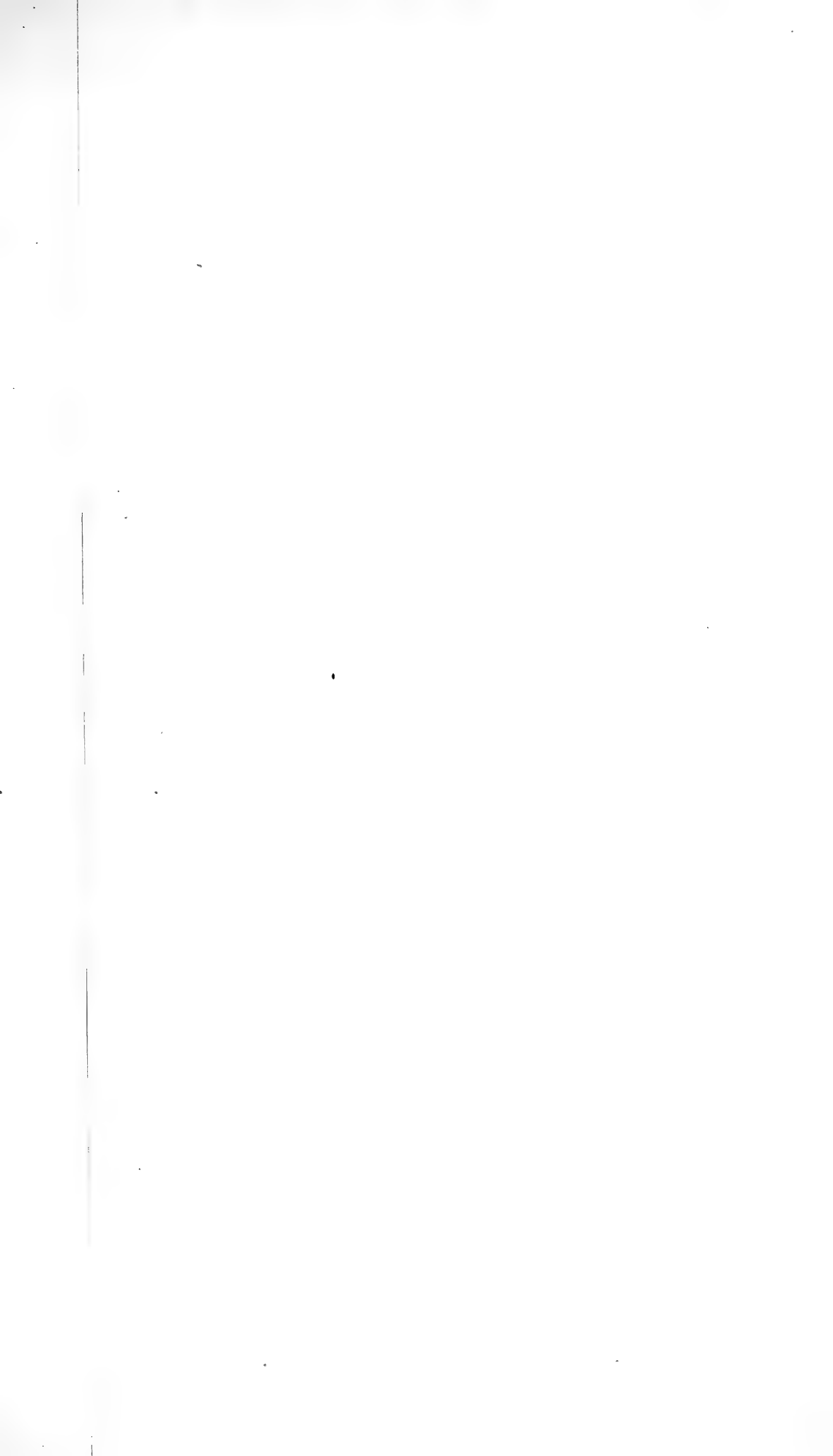


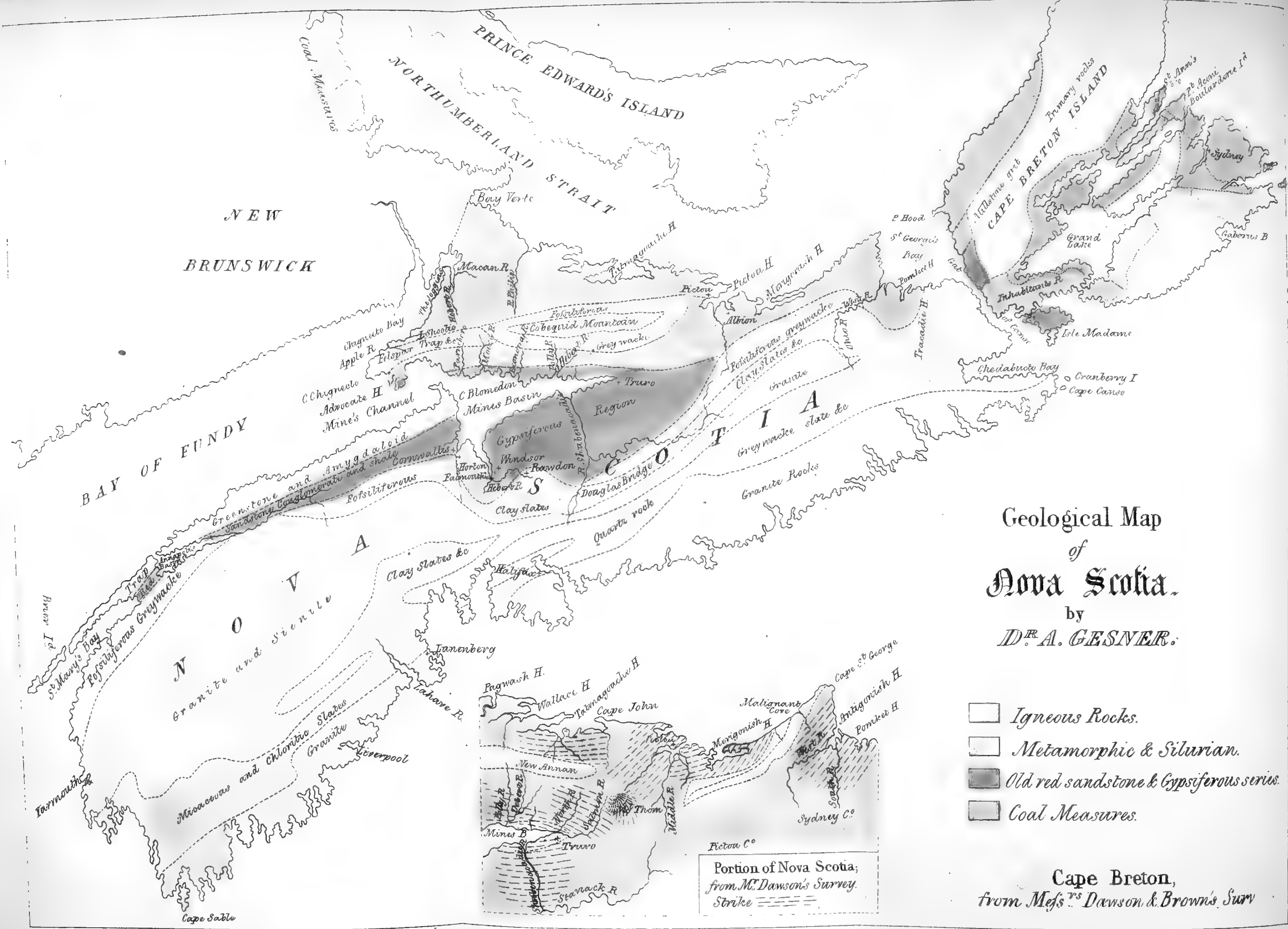
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PART OF NOVA SCOTIA

BY J. W. DAWSON, ESQ.^{RE}

*broken Lines indicate
the prevailing strike.*





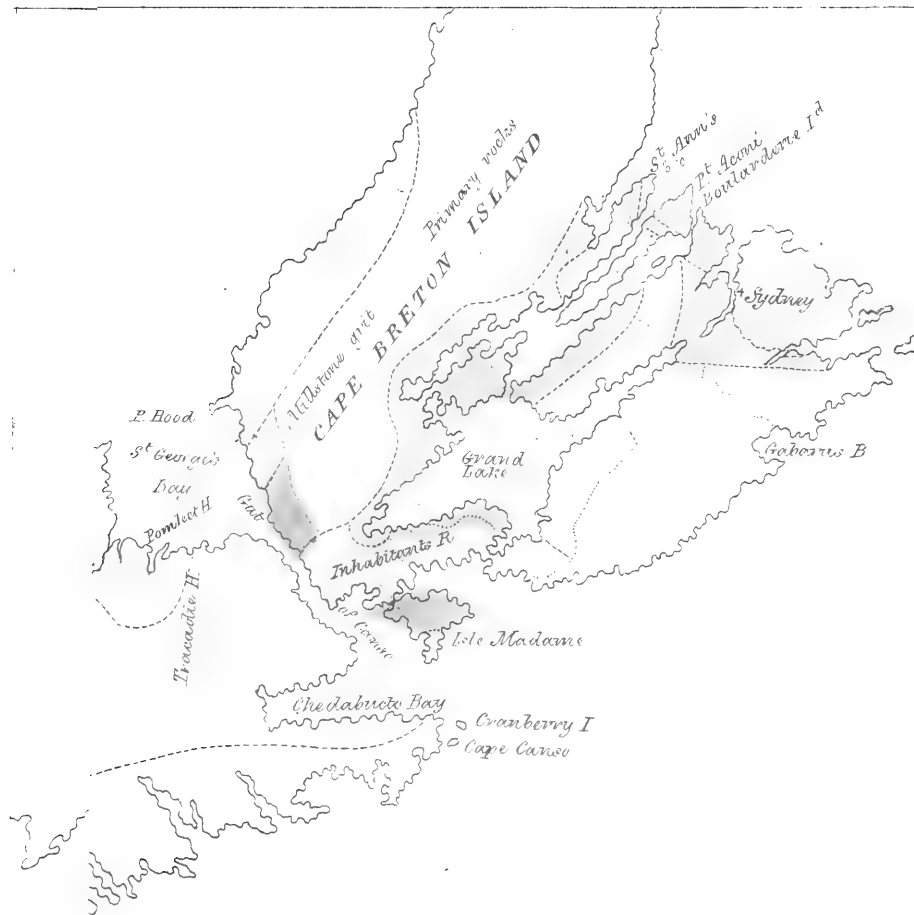


Geological Map
of
Nova Scotia.
by
D^R. A. GESNER.

- Igneous Rocks.*
- Metamorphic & Silurian.*
- Old red sandstone & Gypsiferous series.*
- Coal Measures.*

Portion of Nova Scotia;
from M^r. Dawson's Survey.
Strike

Cape Breton,
from M^{rs}. Dawson & Brown's Surv



Geological Map of Nova Scotia.

by
D.^R A. GESNER.

*Prince
Id.
St. George
nick H.
nick H.*

Yarm.

- ☐ *Igneous Rocks.*
- ☐ *Metamorphic & Silurian.*
- ☒ *Old red sandstone & Gypsiferous series.*
- ☐ *Coal Measures.*

Cape Breton,
from Mefs^{rs} Dawson & Brown's Surv

DECEMBER 13. 1843.

The Rev. Thomas Image, M.A., was elected a Fellow of this Society.

The following communications were read : —

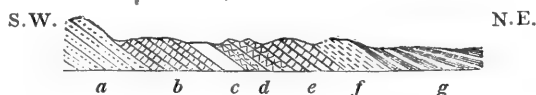
1. *On the GEOLOGY of CAPE BRETON.* By RICHARD BROWN, Esq.*

IN a letter to Mr. Lyell, dated Sydney Mines, Cape Breton, Oct. 20. 1843, the author stated —

“I have made a survey of some forty miles of coast on the eastern side of our coal-field; and have since devoted a few days to the examination of the shores of the Island of Boularderie, which is four miles wide, and twenty-six miles long, and exhibits natural sections on both sides from end to end. Nothing can be more definite than the position of the masses of gypsum in this island. I have examined them this summer in four different places, scores of miles apart, and find the following, with little variation, to be a section of the accompanying strata :

SECTION I. (Ideal).

General sequence of the COAL MEASURES and GYPSIFEROUS FORMATIONS near
SYDNEY, CAPE BRETON.



- | | |
|--------------------------------------|-----------------------------------|
| † g. Coal measures: | c. Soft red shale. |
| f. Coarse sandstone with coal plants | b. Coarse concretionary limestone |
| —Shale. | and shales. |
| e. Limestone in thin beds—Fossils. | a. Coarse conglomerate, highly |
| d. Gypsum. | inclined. |

“Wherever I have had an opportunity of making observations, they have confirmed your views as to the relative age of the gypsum.”

Subjoined is the *Memoir* received from Mr. Brown.

THE following is a sketch of the north-western end of the Sydney coal-field. On the W. side of Sydney Harbour, the coal-measures can be traced transversely, without interruption, for 5200 yards, dipping to the N. E. at an angle of 7° , which gives a thickness of 1900 feet. The coal measures, generally speaking, are very free from faults.

* This paper and the next (Mr. Dawson's on Nova Scotia) are both illustrated by the map of Nova Scotia appended; but the map was originally prepared by Dr. A. Gesner to illustrate the paper of which a notice has already appeared in the “Proceedings,” vol. iv. p. 186. One portion of the map is repeated, and coloured according to Mr. Brown's survey.

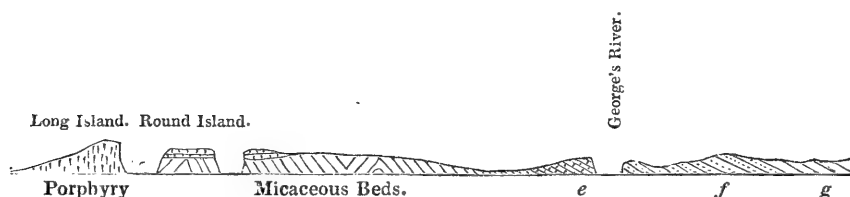
† These references are continued throughout the paper in the other Sections.

The coal-measures are underlaid by a series of sandstone beds, with some beds of shale. The thickness of the sandstone, in some places, exceeds 2000 feet; but to the west of the Little Entrance it is much thinner; and, finally, when it approaches the granite ridge that lies between the Great Entrance and St. Anne's Harbour, it has thinned out. The sandstones, with their superincumbent coal-measures, are very uniform in their dip to the north-east.

Next to the sandstone is the limestone; and this accompanies the sandstone very uniformly, along the whole course of its outcrop, from the southern branch of Sydney Harbour to the Granite ridge west of the Great Entrance. On both branches of Sydney Harbour, and at George's River, the limestone dips distinctly beneath the sandstone. The shore, from George's River to Long Island, gives the following Section,

SECTION II.

LONG ISLAND to the COAL MEASURES East of GEORGE'S RIVER.



First we have the limestone (*e*); then a low, flat space of half a mile, where the stratification cannot be observed; then beds of a red and brown micaceous slaty rock, dipping at high angles in various directions between south and west.

The base of Round Island is of the same kind of rock; but the Isle is capped with a limestone which, to judge from its fossils, is quite different from the limestone * above described beneath the sandstone. Long Island, on its eastern side, is 200 feet high, and very precipitous; but, in a westerly direction, it slopes gradually to the water. It is composed principally of Porphyritic rocks.

On the opposite side of the channel, the shore exhibits the following section:—

SECTION III.



First, the sandstone (*f*) which underlies the coal-measures, and can be traced to within a few hundred yards of Roe's Point.

At Roe's Point the limestone (containing here *Productus Lyelli*) shows itself, having an easterly dip. This limestone, both in its local position, dip, and general appearance, corresponds with the limestone on the other side of the channel, at George's River;

* This limestone contains *Terebratula elongata*, and a *Modiola*.

and these circumstances lead to the supposition that in both instances it dips under the sandstone. Between Roe's Point and Campbell's Cove, on the western shore of the Island of Boularderie, the strata are very much broken and disturbed by faults. It would be difficult to describe these disturbances by words; but the Section will give the most distinct idea of them. Gypsum appears along this line in two places, which are shown in the Section.

First, to the N. W. of Roe's Point, we have solitary pinnacles of gypsum appearing on the beach. Next, three beds of limestone, with two of sandstone interposed, these beds all dipping in an opposite direction to those at Roe's Point. The middle bed of limestone contains *Productus spinosus*. The third and upper of these limestones is cut off by a vertical fault, which is succeeded by a flat arch of limestone, resting upon sandstone. This again is cut off by a vertical fault, which is succeeded by a horizontal bed of limestone.

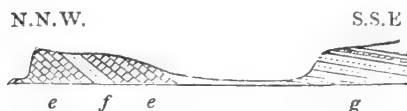
This is followed by a level space; and beyond that we have a series of beds dipping in the same direction with those of Roe's Point.

- | | |
|-------------------------------------|---|
| 1. A thin bed of limestone. | 5. Rich marl, 6 feet. |
| 2. A bed of sandstone. | 6. Green sandstone, with veins of gypsum, 2 feet. |
| 3. A thick bed of coarse limestone. | 7. Red marl, with grains of gypsum, 12 feet. |
| 4. Gypsum, 18 feet thick. | |

This is followed by a level space, when no beds are seen, and beyond that we have limestone, dipping in the same direction with the gypsiferous marls.

SECTION IV.

CAMPBELL'S COVE, near LIME POINT.



Proceeding from Campbell's Cove along the shore of the Island of Boularderie in a south-westerly direction, we have similar limestones, lying in a horizontal position, for the space of two miles, until we arrive at Lime Point, where a small cove exhibits three beds of limestone with two interposed beds of sandstone dipping to the S. S. E., and apparently underlying the sandstone with coal-plants; but separated from it by a space which affords no section. The lowest of the three beds of limestone contains *Spirifer glaber* (Lyell); the middle bed contains shells.

The writer mentions in his letter to Mr. Lyell that, "on the eastern side of the Sydney coal-field, he has found below the coal-seams, in every instance, beds of fire-clay, containing the long fibrous leaves of *Stigmaria*, matted together.

"In the black bituminous Shale, which lies about twenty yards

above the Main Coal at Sydney, he has found the scales of different kinds of fishes, as hard and bright as enamel ; one tooth, and a number of Coprolites ; also the *Cypris* in great abundance, and a *Modiola*."

2. *On the LOWER CARBONIFEROUS ROCKS, or GYPSIFEROUS FORMATION of NOVA SCOTIA.* By JOHN WILLIAM DAWSON, Esq., of Pictou, Nova Scotia.*

THE coal formation of the eastern part of Nova Scotia consists of a great thickness of sandstones, shales, and conglomerates, of various reddish and grey colours, the former being most prevalent. The lower part of the series is distinguished by the presence of limestones with marine shells and gypsum. Its central portion is characterised by a greater prevalence of grey and dark colours, and by containing an abundance of vegetable fossils and beds of bituminous coal. The upper portion of these productive coal measures appears to pass into a thick deposit of reddish sandstones and shales, containing few fossils, either animal or vegetable. To examine the structure and relations of the lower, or gypsiferous part of this series, is the object of the present paper : it will, however, be proper in the first place to notice the general disposition of the rocks of the Carboniferous system, in the region more particularly observed, which extends along the shores of the Gulf of St. Lawrence, from Tatmagouche to Antigonish Harbour.

The coast section between these points cuts at acute angles across two great coal troughs, the one beginning at Pictou, and thence stretching to the west along the northern shore of the Basin of Mines ; the other beginning at Antigonish, and thence extending westward to the Stewiacke and Shubenacadie Rivers. These two troughs are separated by a hilly range composed of igneous rocks and of disturbed lower-carboniferous and Silurian strata. This range beginning at Cape St. George extends westward to the East River of Pictou ; and beyond this it is continued along the outcrops of the oldest carboniferous rocks in the direction of Truro.

The southern boundary of the Antigonish trough is formed by the region of Palæozoic, metamorphic, and Plutonic rocks which occupy the southern side of the province. A chain of hills, similar in structure to the range of Cape St. George, but of greater elevation, separates the Pictou trough from a region belonging to the coal strata which extends beyond Tatmagouche in a northerly direction.

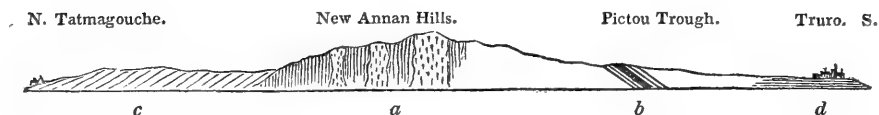
The chain in question commences at the New Annan Hills, and extends westward through the Cobequid Mountains† to the Bay of

* See the map of Nova Scotia.

† Dr. Gesner, many years since, described the Cobequid chain as forming a ridge separating the coal-formation of the north side of the Basin of Mines from that of Cumberland county. Mr. Logan first noticed the existence of a trough of carboniferous strata between Antigonish and Windsor.

SECTION I.

TATMAGOUCHE TO TRURO, 24 miles.



d. Horizontal red sandstone.

c. Red and grey sandstones and shale, with concretionary limestone, containing copper ore, *lignite*, *Endogenites*, and *footmarks of birds*; dip near the hills, 30° ; at Tatmagouche only 10° .

b. Sandstone and coal—*coal-plants*.

a. Limestone, dark slate, shale, and grits, with shells and encrinites—Intruding bands of granite, syenite, amygdaloid, &c.

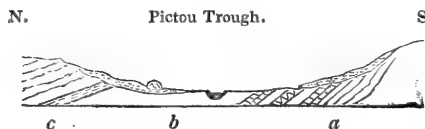
Fundy. To the eastward it does not reach the coast of Northumberland Strait, though its underground continuation in that direction is indicated by an Anticlinal line which traverses the newer members of the coal formation that lap round the eastern extremity of the Annan Hills.

These trough-shaped arrangements of the strata are subject to many irregularities. The hilly region of Mount Thom is placed nearly transverse to the Pictou trough. In consequence of the separating ridges and anticlinal lines having been elevated, either during the carboniferous period, or at a still later epoch, the carboniferous strata are traversed by numerous faults and minor lines of disturbance, the prevailing direction of which is from east to west. In spite of these disturbances, however, the strata in the troughs have a general synclinal arrangement which can be traced in the hilly regions, such as that of Mount Thom. This will be seen by examining the accompanying map.

East River.

SECTION II.

Valley of the eastern branch of EAST RIVER.



c. Hard sandstone.

b. Gypsiferous formation, with beds of limestone and gypsum alternating, and drifts overlying.

a. Silurian slate.

gypsum (b). These latter are seen in the valley of the river between the sandstones and the Silurian strata (a); but there are no good

The gypsiferous formation appears in several places on the south side of the Pictou coal trough. In noticing its appearance at these points, I may begin by stating some facts respecting the section on the East River of Pictou in addition to those already described by Mr. Lyell. The members of the gypsiferous formation seen in that section consist of hard, brownish-red shales and sandstones (c), with beds of marine limestone and masses of

sections to be found in the neighbourhood. With the view of ascertaining their true relations, I examined two gypsum rocks, within three miles of that seen by Mr. Lyell. The first of these consisted of white granular gypsum, containing, like most similar beds in this province, minute disseminated grains of carbonate of lime, and having, in one part, large rounded masses of anhydrous gypsum, enclosed in the common species, an appearance which I have not elsewhere observed. No other rock was seen in connection with this bed, which appeared to be upwards of 100 feet thick, and to have a strike corresponding with that of the nearest visible sandstones and limestones. The other bed examined was on Lime Brook, a tributary of the East River. Here there is no good section, but the gypsum may be seen in connection with soft sandstones mostly white, and having limestones both below and above, separated, however, by intervals without section, which have probably once been occupied by soft sandstones removed by denudation. The limestone, underlying the gypsum at Lime Brook, is without fossils, and rests unconformably on the edges of slates with Silurian fossils, angular fragments of the slate being included in its lower portion. The limestone above the gypsum is of a lighter colour, and more pure than any other limestone on the East River, and is also distinguished by containing a species of coral, not found in the other beds. These limestones are seen at several other points, apparently resting on the older slates; and in some places appear to be penetrated by fissures containing hæmatite and other ores of iron, peroxide of manganese, and sulphate of barytes.*

The limestones and gypsums thus resting on the Silurian strata at the East River are separated from the productive coal measures by hard reddish sandstones and shales, apparently of great thickness, and containing (especially in their lower part) beds of marine limestone. Where they approach the coal measures, however, the sandstones are very much disturbed, and for this reason I was anxious to obtain some additional evidence of the actual superposition of the coal measures. I therefore examined the section shown by the Middle River, and found there a series of beds dipping in the same direction with those at the Albion mines, though at a higher angle, and beginning at about 5000 feet below the main coal at the Albion mines. The uppermost of these rocks is a thick bed of hard grey sandstone; underlying this are alternations of grey and reddish sandstones and shales, containing in one place a bed of bituminous shale, with *Calamites* above, and cylindrical leaves or roots, perhaps of *Stigmaria*, below. Beneath these are several hundred feet of red and variegated sandstone, with shale and conglomerate. Here there is a break in the section,

* The balls of hæmatite scattered over the country, near the gypsums of the East River, have been derived from these fissures in the gypsiferous rocks; and their abundance is an additional evidence of the denudation which these rocks have suffered.

and these rocks are succeeded, farther up the river, by disturbed sandstones and limestones, which I was unable to examine, but which I believe to correspond with those of the East River.

From these observations, in connection with those formerly made by Mr. Logan and Mr. Lyell, it is apparent that the lowest members of the Carboniferous series seen on the East River consist of limestones, gypsum, and soft sandstones, above which are hard reddish sandstones and shales, with limestone; and lastly, red and grey sandstone, shells, and conglomerate, with carboniferous plants, and probably these beds pass into the productive coal measures.

On the south side of the West River of Pictou, limestones, having the same fossils with those found on the East River, are seen in several places, and are associated with reddish sandstones, hard grey shales, and white and purple sandstones. Farther westward, near the Salmon River, there are sandstones, limestones, and gypsum, identical in fossils and mineral character with those of the East River, and like them connected with productive coal measures, which they appear to underlie. Still farther westward, the gypsiferous formations of Onslow and the De Bert River probably form a continuation of the Pictou lower carboniferous deposits, being, like them, succeeded to the northward by the middle and newer members of the coal formation.*

Merigonish.

SECTION III.

MERIGONISH to MALIGNANT COVE, 20 miles.



e. Coloured sandstones and shales, with occasional bands of ironstone and concretionary limestone in the upper part—*Calamites* and other coal plants. Coal?.

d. Limestone and conglomerate—*fossil shells*.

c. Amygdaloid and conglomerate overlying sandstones and containing *plants*.

b. Dark shales with thin beds of limestone, a little conglomerate, and reddish grits—*marine shells*, *Encrinites*, *Trilobites*, &c.

a. Altered red sandstone and conglomerate with dark shales, beds of amygdaloid, and intruding masses of greenstone.

Eastward of the East River, the band of carboniferous rocks included between the shores of the gulf and the hills to the southward, shows a series of beds, amounting to 10,000 or 12,000 feet in thickness, and dipping to the north-west at an angle of 20 degrees. The upper part of this section, beginning at the entrance of Meri-

* The salt springs of the West River rise from lower carboniferous rocks, those of Salmon River from the productive coal measures. In both instances they rise from vertical strata on lines of fault.

gonish harbour, shows grey and brownish-red sandstones and shales, buff-coloured sandstones, impure iron-stone, and coarse concretionary limestone, these beds containing *Calamites*, coniferous wood, and one or two small beds of coal. This part of the section is, however, very imperfect, though, wherever the rocks can be seen, there is a perfect conformity of dip. Their general aspect and fossils correspond with those of the middle part of the coal-formation, and they occupy about six miles of the coast section.

Eastward of the rocks last described, the section is better, and shows a great thickness of brownish-red sandstones and shales, with some grey beds, in which I could not find any fossils, except some carbonised fragments of plants. These strata occupy about three miles of the section, and are underlaid by reddish conglomerates, containing two beds of dark grey limestone, having an aggregate thickness of about 80 feet. These limestones contain numerous fossils, among which are *Productus Martini*, *Spirifer glabra*, and other shells, all common to these beds and the limestones of the East River. These conglomerates and limestones are succeeded by a few hundred feet of thinly stratified, reddish and grey sandstones, with a few fragments of fossil plants in bad preservation. Beneath these, red conglomerates again appear, associated with amygdaloidal trap. The latter is of a grey colour and earthy aspect, and has its cells filled with white carbonate of lime. It constitutes two conformable beds, whose lower sides are more compact than their upper. Their upper surfaces are also partially broken up and intermixed with conglomerate. At this point the carboniferous rocks are cut off on the coast section; some hard brownish grits, however, seen in a neighbouring brook, called M'Cara's brook, probably underlie the rocks last mentioned.

The section between M'Cara's brook and Arisaig is occupied by dark shales and thin layers of limestone, with a few beds of reddish shale and conglomerate. These rocks dip S. W., but become much fractured as they approach Arisaig. They contain numerous fossils, including species of the genera *Tentaculites*, *Graptolites*, *Trilobites*, *Orthoceratites*, *Modiola*, *Productus* and *Conularia*, and remains of *Encrinites*. Though mostly Silurian, a few of these species appear to be the same with those of the slates of the East River. Rocks having the appearance and fossils of the latter are, however, found a short distance inland, to the southward of the shales.

There can be little doubt that, in the sandstones, limestones, and conglomerates of this section, we have the representatives of at least a part of the Gypsiferous formation of the East River, and, resting conformably upon these, an equivalent of the coal-measures.

Arisaig.

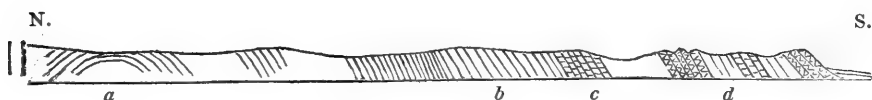
At Arisaig, 15 miles from Merigonish harbour, we enter on the disturbed district, separating the coal-trough of Pictou from that of Antigonish. From Arisaig to Malignant Cove, the shore

displays hard brownish-red quartzose and jaspery rocks, with thick beds of hard grey shales, red conglomerates, and coarse purplish grits. Associated with these, are beds of amygdaloid, which are evidently interstratified with the accompanying rocks, and are probably, like those of M'Cara's brook, of contemporaneous origin. The whole of these beds are vertical, and are, without doubt, lower carboniferous rocks (perhaps a little lower in the series than those last seen at M'Cara's brook), but in a much altered condition. Beyond Malignant Cove, syenitic greenstone is seen on the shore, and, is said to appear in different places as far as Cape St. George. Eastward and southward of Malignant Cove, the hills, in many places, show masses of compact felspar and other igneous rocks, accompanied by altered and disturbed grits. After passing this disturbed region, we enter on the Gypsiferous rocks of the northern side of Antigonish harbour, having a general dip to the southward. Of these rocks, I examined two interesting sections.

Antigonish.

SECTION IV.

RIGHT'S RIVER, ANTIGONISH.



d. Gypsiferous beds—gypsum, limestone, and sandstone.

c. Limestone.

b. Red conglomerate and coarse red sandstone, dark sandstone and shale.

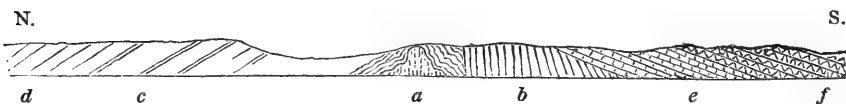
a. Dark and grey sandstones and shales, reddish sandstone: —plants.

The first of these sections is that represented above, and is seen extending about five miles. Near the mouth of this river, at the head of Antigonish harbour, is a thick bed of white gypsum, dipping to the south-west. Succeeding this, in descending order, after a small interval (which appears to have been occupied by sandstones, now nearly removed by denudation), is a bed of dark-coloured limestone, in which, at different points where it appears, I found *Productus Martini* with other shells also occurring on the East River; and *Productus Lyelli*, a shell not yet met with in the East River limestones, but very characteristic of the gypsiferous formation in other parts of the province. Below this limestone there is another break, also showing traces of sandstones and a bed of gypsum, and then a thick bed of dark limestone, partly laminated and partly brecciated without fossils, and containing in its fissures thin plates of copper ore. Beneath this limestone is a great thickness of reddish conglomerate, composed of pebbles of igneous and metamorphic rocks, and varying in texture from a very coarse conglomerate to a coarse-grained sandstone. In one place it contains a few beds of dark sandstones and shales. These are succeeded by red, grey, and dark sandstone and dark shales, in a disturbed condition, but probably underlying

the conglomerate ; they contain a few fossil plants. This section on Right's River includes a thickness of probably 8000 feet.

SECTION V.

OGDEN'S LAKE to SOUTH LAKE, near ANTIGONISH (4 miles).



- d. Grey sandstone, and red conglomerate.
- c. Soft red sandstones and clays ; *lignite*, *calamites*, &c.
- a. Altered dark sandstones and shales ; intruded greenstone.
- b. Grey and soft red sandstones and shales.
- e. Limestone.
- f. Gypsum.

Another section, near the mouth of Antigonish harbour, displays a series somewhat similar. At the north side of the outlet of Ogden's Lake, about eight miles from Antigonish, is a bed of gypsum, probably nearly 200 feet in thickness. Its upper part is composed of white granular gypsum, in thick laminae, and with disseminated particles of carbonate of lime. Beneath this is a considerable thickness of foliated red gypsum, in its lower part alternating with layers of a grey argillaceous non-crystalline limestone, on which it rests, and which is penetrated by small veins of white fibrous gypsum in its upper portion, while below it becomes brecciated, and then laminated. It is probably 100 feet thick, and appears to contain no fossils. These great beds of gypsum and limestone dip to the S. S. E. at an angle of 25° , and rest unconformably on soft red sandstones and shales, with some grey sandstones and reddish conglomerate, dipping nearly in the same direction, but at an angle of 50° . Following this underlying series in the descending direction, it becomes more highly inclined, and is finally vertical, resting against a mass of altered and contorted dark shales and sandstones, with veins of greenstone containing much epidote. This part of the section is connected with a ridge of igneous rocks running in an east and west direction, and which a few miles farther inland attains a considerable elevation. It consists of a reddish syenite, quartz, compact felspar, and greenstone. After passing these disturbed rocks, there is a break in the section, which is next occupied by thick beds of brownish-red sandstone and clay, supporting a thin bed of conglomerate and some thick beds of grey sandstone, containing *Calamites*, *Sternbergia*, *Endogenites*, *Carpolites*, and pieces of lignite. The relations of these beds to the other parts of the section I could not determine. They dip to the north-east, and probably belong, either to the upper part of the gypsiferous formation, or to some newer member of the coal series.

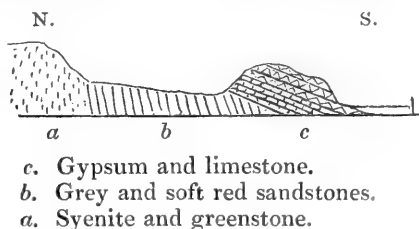
These sections differ from that of the East River of Pictou, chiefly in the presence of large masses of sandstone and conglomerate beneath the limestones, and in the non-appearance of the thick series of sandstones above the gypsum, so conspicuous in the Pictou sections.

Shubenacadie.

Having thus described the Lower Carboniferous rocks, as they appear in some of the best sections near the Gulf of St. Lawrence, it may be interesting to compare their arrangement and lithological character with those of the Gypsiferous formations of the central part of the province, formerly supposed to be newer than the coal-formation, but referred by Mr. Lyell, principally on the ground of its fossils, to the lower part of the Carboniferous system. The rocks seen on the estuary of the Shubenacadie furnish a good specimen of these deposits for the purpose of comparison. The sections on this estuary show several extensive masses of stratified deposits, differing considerably in their mineral character, and separated by faults in such a manner that their true relations do not appear. Most of these masses consist of Red sandstones and marls, with beds of gypsum and limestone. These, when compared with the corresponding rocks in the Pictou and Antigonish sections, appear to differ only in their apparently greater mass, and especially in the thickness of the deposits of red sandstone and marl. The upper bed of gypsum on Right's River is succeeded by a level tract affording no section; and from the two sections, representing the outline of the surface near the gypsum of Ogden's lake and the East River, it will be seen that the present outline of the surface is caused by a great removal of the softer beds.

SECTION VI.

Near OGDEN'S LAKE, ANTIGONISH (showing denudation).



One of the most remarkable rocks on the banks of the Shubenacadie is a great bed of compact and laminated non-fossiliferous limestone, near the mouth of the estuary. This bed has its upper surface broken up into a kind of breccia, and supports a great thickness of soft red sandstone and conglomerate, with beds of gypsum. It is also traversed by fissures filled with hæmatite and ores of manganese. It rests upon a great thickness of hard, brownish grits and shales, which appear in different places on the road from Shubenacadie to Truro. The horizontal red sandstone of Truro rests on the edges of these grits, which, near Truro, become either vertical or dip rapidly to the north-east, and perhaps also underlie some of the gypsiferous rocks of the Onslow hills. From a consideration of all these circumstances, it appears probable that these hard grits are the equivalents of the lower grits and conglomerates of Antigonish; and that the bed of limestone which

they support is a representative of the lower limestone at Antigonish and Pictou. To the lower grits I would also refer the mass of dark red sandstones and shales at Eagle's Nest, three miles from the mouth of the estuary of the Shubenacadie. The mass of contorted dark sandstones and shales at Five-mile River resembles some parts of the productive coal formation more nearly than any of the lower carboniferous rocks : and the horizontal red sandstone, a few miles farther up, is analogous to many of the beds both above and below the gypsum at Antigonish and Pictou.

From a comparison of the appearances of the lower carboniferous rocks in the various sections which I have examined, I have drawn out the following table, which, I think, exhibits very nearly their general arrangement. It commences with the productive coal measures.

Lower Carboniferous or Gypsiferous Formation.

Rocks.	Fossils.	Where seen.
1. Brownish-red, mottled and grey sandstones ; brownish-red shales ; some conglomerates ; the beds containing small quantities of copper ores.	Endogenites, Calamites, Lepidodendron.	Merigonish, East River, Middle R., Shubenacadie ?
2. Brownish-red hard sandstones and shales, often rippled ; some grey sandstones, conglomerates, and limestones ; copper ores in small quantity.	Fragments of plants and fucoidal markings ; Productus (especially P. Martini), Terebratula, Spirifer, and other shells.	East River, Merigonish, West River, Middle River, Economy, Wardrobe's, on Shubenacadie ?
3. Reddish and white sandstones and marls, usually soft ; beds of gypsum and limestone (the lowest bed usually a non-fossiliferous limestone) ; veins and fissures with ores of iron, manganese, copper, &c.	Productus (especially P. Lyelli), Terebratula, Encrinites, Corals, Spirifer, Pecten, Avicula, &c. &c.	East River, Antigonish, Shubenacadie, Onslow Mountain, De Bert R., Windsor, Pugwash, Wallace, &c.
4. Reddish-brown conglomerates and hard grits ; some dark and grey sandstones, and brown and dark shales.	Various plants.	Antigonish, Shubenacadie, Truro, Salmon R.

Newer Coal Formation, Sandstones, &c.

In several parts of the eastern section of Nova Scotia, there are extensive deposits of sandstones and shales, principally of a brownish-red colour, and including some thin beds of concretionary limestone and grey sandstone. They contain a few calamites and other carboniferous plants. These beds constitute, I believe, the newest member of the carboniferous series, and are connected with the productive coal measures by a thick series of reddish-brown and grey sandstones, shales, and conglomerates, often abounding in

fossil plants. As these upper red sandstones have, however, been confounded with the gypsiferous formation, some of whose sandstones they often much resemble, I may shortly describe a section on the Waugh's and French rivers of Tatmagouche, exhibiting a portion of them, and at the same time illustrating the structure of a part of the Cobequid chain.

At the mouth of the French river are grey sandstones and shales, containing a few endogenites, calamites, and pieces of lignite, impregnated with copper ores. Beneath these appears a series of brownish-red sandstones and shales, with a few grey beds, occupying, in a regular descending series, about six miles of the river section. They contain, in a few places, nodules of copper glance, they are often rippled, and contain branching fucoidal marks. On one of the rippled slabs I found marks consisting of four foot-prints of an animal. These were three inches and a-half apart, and each exhibited three straight marks, as if of claws.*

The dips of these sandstones gradually increase in approaching the hills, and the lowest seen is a bed of grey sandstone, dipping at an angle of 30° . There is then a small break in the sections, succeeded by hard dark shales and slates, and hard brown grits, with a bed of limestone in which I could find no fossils, except a fragment of a *Productus* and a few fragments of encrinital stems in bad preservation. These rocks are much disturbed, but generally appear to dip at high angles to the northward. They are associated with masses of greenstone, amygdaloid, reddish syenite, and other igneous rocks. They appear to rise unconformably from beneath the sandstones of the low country; but whether they belong to the lower carboniferous or to some older system, I cannot at present determine.

I hope, at some future time, to be able more particularly to state the structure and relations of the newer members of the coal formation, but have not yet collected a sufficient quantity of facts to determine accurately their relations.

The horizontal red sandstone of Truro, which skirts the Basin of Mines, has no connection with the red sandstone of Tatmagouche, but is probably newer than any part of the coal formation. It is destitute of the grey sandstones and shales, and in several sections of it which I have examined, I have not found any fossils.

3. *On CONCRETIONS in the RED CRAG at FELIXSTOW, SUFFOLK.*

By the Rev. J. S. HENSLOW, M.A., F.G.S., Professor of Botany in the University of Cambridge.

I PLACE on the table a selection from a large assortment of a peculiar description of concretions obtained from the Red Crag at

* These tracks resemble the marks of the claws of an animal *running* over a moderately firm surface, or *climbing* up an inclined plane. They are not unlike the marks left by the claws of small individuals of the River Tortoise on the sides of mud banks, but differ from them in showing traces of two feet only.

Felixstow, in Suffolk. In 1842 I was much puzzled to account for the nature of these concretions. At a cursory glance one might almost be inclined to pass them by as waterworn pebbles, as they lie abundantly interspersed among the comminuted shells which form the upper parts of the cliffs. I found more than one eminent geologist disposed to agree with me in considering them to be rolled masses of London clay which had been indurated subsequently to their deposition in the crag. On my again visiting Felixstow during the summer of the present year (1843), I determined to give them a particular examination; and although a formation which has been so thoroughly worked as the crag is not likely to afford a casual visitor the opportunity of gleaning much of novelty, I believe I have satisfactorily ascertained the origin of these concretions, and have added to the list of crag fossils the petro-tympanic bones of at least four species of Cetaceans. These latter, I am persuaded, have been overlooked among the many concretions of this formation. They are, however, of a different composition, and closely resemble, in this respect, the silicified fragments of bone so abundant in this locality. I believe the specimens I have procured will range under two types, each containing at least two species. I am not competent to the task of throwing any osteological light upon these fossils, but am happy to state that Professor Owen has undertaken their examination; and we may therefore expect before long to be in possession of all that can be said about them. It seems to me not a little remarkable, that all these specimens should have been procured within a very narrow compass, for I found none beyond the limits of two contiguous indentations in the cliff, a short distance to the north of Felixstow.

But, to return to the concretions to which I am more particularly desirous of directing attention. They exhibit a very great variety of forms. Many are more or less spheroidal, fusiform, and cylindrical; many are perfectly amorphous. They appear to be composed of a fine-grained compact ferruginous claystone, of a dark chocolate brown colour; but the surface, which is very smooth, and even polished, becomes pale by exposure. They often separate by natural flaws into three or more fragments, which are bounded internally by nearly plane surfaces. Many of them offer traces of organic association; and the result of an extensive examination has convinced me that they must all be considered as of coprolitic origin. I am not aware whether any analysis has ever yet been made of them.

I will now direct attention to the following peculiarities observable in some one or other of the specimens referred to:—

1. Two spiral masses.
2. A large perforated one, with traces of spiral or annular transverse convolutions.
3. Other smaller ones, the convolutions being longitudinal.
4. Common character of the cylindrical and fusiform ones, seen, by fracture, to be formed of *longitudinally* coiled folds, with a perforated axis.

5. Containing more or less distinct traces of fossils, apparently from *macerated* subjects.

Ex. gr. Vertebræ of cartilaginous fish.

Ex. gr. Crustacea, very numerous. N. B. Their remains in the Crag are never thus fossilised unless under coprolitic associations.

Ex. gr. Two echiniform masses.

6. Various forms, more or less amorphous.

7. With vermicular-like traces (*Algæ?*), as in the nodules from Green sand and Gault.

8. With *pitted* surfaces, as if from the escape of bubbles of gas.

9. Ditto on fragments of cetaceous (?) bones highly polished, and perhaps half digested.

10. Another description of nodule, less common, larger and more gritty, often containing organic matter, as shells, &c.

4. APPENDIX to *Professor Henslow's Paper, consisting of a Description of the FOSSIL TYMPANIC BONES referable to four distinct Species of BALÆNA.* By RICHARD OWEN, Esq., F.R.S., Hunterian Professor in the Royal College of Surgeons.

THE fossils from the Crag at Felixstow, which have been submitted to my inspection by Professor Henslow, are the tympanic portions of the petro-tympanic bones of large Cetacea.

The tympanic adhering to the petrous portion by only two small surfaces is easily detached, and may be recognised by its conchoidal shape and peculiarly dense texture; the recent bone breaking with almost as sharp a fracture as the petrified fossils.

None of these are entire: the thin brittle outer plate which bends over the thick, rounded, and, as it were, involuted part, like the outer lip of such simple univalves as the *Bullæ* and *Leptoconchi*, is broken or worn away in the best specimens, all of which are rolled and waterworn.

We are led by the size of the specimens to the largest of the existing Cetacea for the subjects of comparison, as the Grampus, the Hyperoodon, the Cachalots (*Physeter*), and the true whales (*Balænoptera* and *Balæna*).

Two or three of the specimens are fortunately sufficiently entire to show the form of the tympanic cavity bounded by the over-arching plate, with the proportion and direction of its anterior or Eustachian outlet, and most of them have the opposite or hinder extremity entire. We are thus enabled to determine that the majority differ from the tympanic bones of the *Delphinidæ*, including the *Grampus* and *Hyperoodon*, in having the hinder extremity of the bone simple and not bilobed; and some of them, in having the anterior outlet of the cavity partially enclosed by the extension of the outer plate around that end.

With regard to the Cachalot (*Physeter*), I regret that I have had no opportunity of comparing the Felixstow fossils with the tympanic bone in that genus, which I know only by the figures given

by Camper* in his usual sketchy style. Cuvier, who founds his notice of the tympanic bones of the Cachalot on the same figures, states that they most resemble those of the *Delphinidæ*; but are less elongated and less bilobed posteriorly. The figures show still more clearly that the tympanic cavity is continued freely forward out of the anterior end of the bone, and terminates by a relatively wider outlet than in the *Delphinidæ*.

If the idea thus given of the form of the tympanic bone of the Cachalot be correct and conformable to nature, the comparison of the Cetacean fossils becomes limited to the true whales (*Balenidæ*), in the few known species of which the distinctive characters of the tympanic bones are afforded by their relative size and the shape of their inferior surface.

In *Balenoptera* the tympanic bones, according to Cuvier, are very small in proportion to the head, and are equally convex at their inferior surface.

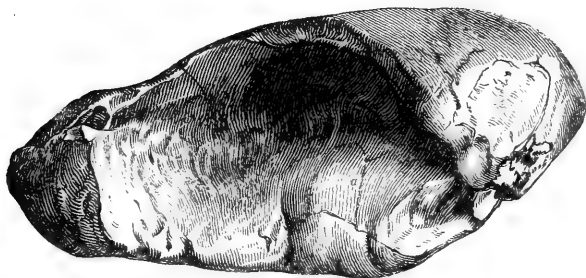
As none of the fossils in question have been found *in situ*, with any part of the cranium, their size in proportion to that of the animal cannot be judged of; but in the specimens that have been least injured and water-worn, the inferior surface shows the flattened or gently concavo-convex undulation which characterises the tympanic bone in true *Balæna*.

In regard to the differences which are observable in the tympanic bones of the two known species of *Balæna* (*Bal. mysticetus*, and *Bal. australis, capensis*, or *antarctica*) Cuvier† merely observes that “though slight they add to the motives which led him to believe the Arctic whale and that of the Cape to be specifically distinct.” This remark at least encourages us to regard the characters derivable from the tympanic bone as sufficiently determinate to be a guide in the distinguishing of species; and with this conviction I have proceeded to compare the fossils in question with the recent tympanic bones of the two existing species of *Balæna*.

In them the thick convex involuted portion of the tympanic bone is slightly and unequally raised above the level of the cavity formed by the over-arching wall, but in the *Bal. antarctica* it gradually decreases in thickness to the anterior or Eustachian angle; while in the *Bal. mysticetus* the thicker posterior part is defined by an indentation from the thinner anterior part. In both species the thinner part of the convex border is distinctly continued to the anterior limit of the cavity; in both the extent of the involuted convexity, inwards, is not well defined, but it gradually subsides, and the convexity is exchanged for the concave curve of the overarching wall. I purposely omit the mention of the slight difference in other parts of the tympanic bone of the *Balæna mysticetus* and *antarctica*, since the condition of the fossils would not admit of the application of those differences in the determination of their affinities.

* Anatomie des Cetacés, Pls. xxiii. xxv.

† Ossemens Fossiles, 4to., v. pt. i. p. 376.

Petro-tympanic bone of *Balæna affinis*.*

One of the most complete of the fossil tympanic bones, which measures five inches in length, resembles the *Bal. antarctica* in the slight elevation of the posterior part of the involuted convexity and its gradual diminution to the Eustachian end of the cavity: it resembles both *Balænæ* in its traceable continuation to that end, and in the gradual continuation of the concave outer wall from the involuted convexity; this convexity is indented also, as in both recent *Balænæ*, by vertical fissures narrower than the marked indentation which distinguishes the *Bal. mysticetus*: these fissures are almost worn out by friction in some of the specimens. The more perfect one under consideration is not, however, identical with the *Bal. antarctica*.

The upper surface of the bone maintains a more equable breadth from the posterior to the anterior end, the outer angle of which, being well marked in the fossil, is rounded off in the recent specimen; the under and outer surfaces of the tympanic bone meet at an acute angle. The above characters are sufficiently marked in the specimens of the fossil tympanic bones to justify their being regarded as belonging to a species distinct from the known existing *Balænæ*, but nearest allied to the *Bal. antarctica*, and which I propose to call *Balæna affinis*.

A second species is more unequivocally indicated by the distinct definition of the involuted convexity; and the extent of the slightly concave surface extending from it to the commencement of the overarching wall; the anterior extremity of the involuted convexity is equally well defined, and a wide concavity divides it from the anterior extremity of the Eustachian cavity. The thickest part of the involuted convexity is not very prominent. The under and outer surfaces of the bone meet at a right angle.

The species indicated by the tympanic bones of this form may be termed *Balæna definita*.

A third form of tympanic bone differs from the first in the shorter and more convex form of the involuted part, the anterior

* This engraving is one of a series (illustrating each of the four species) prepared for Prof. Owen's work on the "British and Fossil Mammalia and Birds" now in course of publication. The cut was very kindly lent by the publisher (Mr. Van Voorst) to illustrate this paper in the "Proceedings."—En.

end of which is divided from the anterior end of the cavity by a concave border one inch in extent; the internal border of the involuted convexity is also better defined than in *Bal. affinis*; but the overarching wall begins to rise close to it, divided from it only by a deep and narrow rugged fissure instead of by a broad and gently concave tract, as in *Bal. definita*.

Both the outer and under surfaces of these specimens are more rounded than in the two preceding species; but being more mutilated and water-worn, the characters derivable from the external parts of the bone are of less value. The characters above specified, which are furnished by the involuted convexity, are decisive as to the specific distinction of the present fossils, which therefore indicate a third species of extinct whale, which I propose to call *Balæna gibbosa*.

There is a fourth form, which differs from the last in the less degree of convexity of the involuted part, but more particularly in its outer border being notched or indented, as in *Balæna mysticetus*, by a vertical angular impression deeper and wider than the smaller vertical fissures.

The comparative shortness of the involuted convexity distinguishes this species from the existing *Balæna* and the *Bal. affinis*, the notched and less convex involution from *Bal. gibbosa*, and the immediate rising of the overarching wall beyond the inner boundary of the involution from the *Bal. definita*. I propose for this species the name of *Balæna emarginata*.

JANUARY 3d, 1844.

Major Thomas Austin, of Bristol, and George Harcourt, Esq., M.P., of Newnham Court, Oxfordshire, were elected Fellows of this Society.

The following communications were read: —

1. *On the Occurrence of the Genus PHYSETER (or Sperm Whale) in the Red Crag of Felixstow.* By EDWARD CHARLESWORTH, Esq., F. G. S.

SOME years since, whilst looking over a collection of fossils in the possession of Mr. Brown of Stanway, I was struck by the appearance of a cylindrical nodule from the Red Crag of Felixstow, which seemed to me to exhibit indications of an organic structure unlike that of any fossil body which had previously come under my notice. With the permission of its owner I had a section made of this fossil; but the characters which it presented upon being cut did not enable me to arrive at any determination respecting its real nature.

At a subsequent period, I learned from Mr. Brown that the nodule in question had been submitted by Professor Owen to microscopical examination, and identified as the tooth of a Cachalot.

In the reports of the British Association for 1842, this tooth is included in the list of British Fossil Mammalia; but Mr. Owen, through mistake, has there assigned it to the "Diluvium of Essex." I am informed by Mr. Brown, that he procured the specimen from a man at Felixstow, who stated that he picked it up on the beach; and as several of the rarest known Crag fossils have been obtained at this spot under similar circumstances, there is no room to doubt its being a genuine fossil of the Crag formation. The mineral condition of the tooth is likewise so very remarkable, and so totally unlike that of the Mammalian remains which occur in the diluvial or lacustrine deposits, that this alone, in the absence of all other evidence, would have sufficed to determine its geological antiquity.

The valuable communication submitted to the last meeting of the Geological Society by Professor Henslow, upon the discovery of Cetacean remains in the Red Crag of Felixstow, immediately brought to my recollection the existence of this Cachalot's tooth in the cabinet of Mr. Brown; and that gentleman having, within the last few days, been so good as to forward the specimen to me, I am now enabled to submit it to inspection. Through the kindness of Mr. Nasmyth I have had the opportunity, upon this occasion, of comparing the structure presented by the fossil with sections of recent Cachalot's teeth, and the result has been to satisfy me of the correctness of Professor Owen's determination.

A species of the genus *Physeter* may therefore now be added to the four species of Red Crag *Balænae* already enumerated by Professor Owen, and the occurrence of this genus must, I think, be regarded as a very interesting addition to the list of Cetaceans discovered by Professor Henslow in the Felixstow cliff.

2. *On a FOSSIL FOREST in the Parkfield Colliery near Wolverhampton.* By Mr. HENRY BECKETT.

THE fossils alluded to in the following notice, occur in an open work, that is, the superincumbent strata have been pared off, and we find the coal (which belongs to what is called the "bottom coal,") well exposed to view. The bed has been bared for upwards of two years, but the fossils do not appear to have attracted attention, till Mr. William Sparrow and myself, whilst tracing the great faults of the South Staffordshire coal-field, accidentally stumbled upon them, and were struck with their number and their evident resemblance to trunks of trees.

Since that time, by the kind permission of the Parkfield Company, and with the assistance of Professor Orlebar, of the Royal Bengal College in Bombay, I have carefully removed the coal attached to the roots of one of the trees.

We found the stump to be perfectly bituminized, but broken off about two inches above the level of the coal measure, the inner

part being somewhat hollowed to about the level of the coal itself: the surface and edges of the broken part were smoothed or probably water-worn. The tree bared was not flattened, but preserved precisely the same appearance which I have noticed with peat timber in Ireland, and was 4 feet in circumference. The principal root extended southwards 22 inches, terminating abruptly. The other roots spread out in a similar manner,—not in separate forks, but in an apparently continuous mass, showing that the plant required a broad base for its support. There were no appearances of a tap root; in fact, the nature of the tree would not require it; neither were any fibrous filaments visible. The trunk and roots were covered with a bark about half an inch thick, the coaly matter of which being more brittle, though considerably more compact in its texture than either the body of the tree or the circumjacent bed, also possessed a more smooth and bright surface, when broken.

The bark externally was either perfectly smooth, or marked by irregular longitudinal striæ, differing altogether from *Calamites* or *Sigillariæ*. Within the bark was the hollow cylindrical trunk, about 2 inches across the cylinder, the coal composing which was, as before observed, more earthy in its character, but was concentrically lamellar in its structure; some thin laminæ being of a brighter and better quality than the mass.

The interior of the plant was filled with a blended mass of coal and shale.

The trees are all upright and bear undoubted evidence of having grown on the spot.

The thickness of coal in which the stumps are found is only 5 inches. On breaking the coal *with the grain*, we met with impressions (very faint however) of reed-like plants and *Stigmaria*.

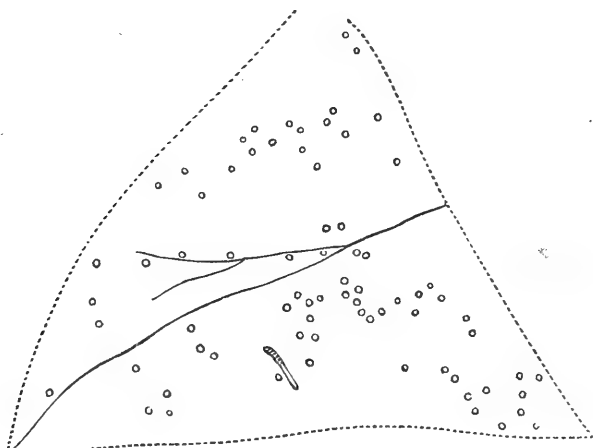
Beneath the coal was the bed in which the trees must have grown, and this (as now compressed and indurated) is $3\frac{1}{2}$ inches thick. It is composed, at the top and bottom, of a dark-brown or brown-black bituminous shale, inclosing a band of fire clay, half an inch thick.

The shale bed contains impressions of the *Lepidodendron*, *Ulodendron*, *Stigmaria*, and probably other species of plants, and I discovered one fragment proving the existence of animal life—a solitary scale of *Megalichthys Hibberti*.

It is remarkable that, though our field in general abounds with the bivalve shells often described as *Unios*, I have only found one specimen in the open work, and that in an upper bed.

There were no appearances of the roots passing into the shale; but from the peculiar arrangement of the central part of the trees, I am induced to suspect that the shale may have occupied an internal position considerably above the level of that in the bed.

On breaking through the shale, we discovered in a second seam of coal what at first struck us as being a prolongation of the roots; but, on further search, another forest was found below the first. In the upper bed we counted seventy-three trees in



about a quarter of an acre (as shown in exact position on the accompanying sketch), and in the second they appeared equally abundant, as we laid bare three trees in as many yards square. The characters of the lower trees were similar to those described, but longer portions of the trunks were developed, the thickness of coal being seventeen inches in the spot opened; but this varies in other parts of the bed. These trees do not pass through the upper shale, but the trunks occupy the whole thickness of this second coal-bed, and we found the substratum to consist of a shale, similar to that above, and 5 inches thick; while below this was a bed of fire clay, seven inches thick, reposing upon a third bed of coal in which trees were not found.

I should perhaps add that the upper coal is capped with fire clay, in which no traces of the trees have been observed.

3. *Description of the Remains of numerous FOSSIL DICOTYLEDONOUS TREES in an Outcrop of the Bottom Coal at Parkfield Colliery, near Bilston.* By WILLIAM ICK, Esq., F. G. S.

At a depth varying from forty to fifty yards below the Ten-yard stratum of the South Staffordshire coal-field, there are usually found three deposits of coal, called the *Top*, the *New Mine*, and the *Bottom Coal*. When these beds can be readily worked, they are scarcely inferior in value to the Ten-yard coal, the *Top* and *New Mine* deposit, with the intervening shales and partings, often forming a series of strata eight yards in thickness. Below this a few beds of ironstone occur; then a bed of fire clay about three yards in thickness, and immediately under this the *Bottom Coal*.

At Parkfield Colliery, $1\frac{1}{2}$ miles west of Bilston, and at about the same distance south of Wolverhampton, there is a fine outcrop of this *Bottom Coal*, which is now being got in open work. In

one part the overlying fire clay has been removed, and the surface of the coal exposed, over an area of a somewhat triangular shape, for about 2,700 square yards.

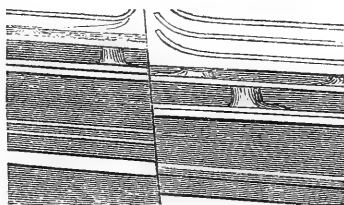
This terrace of coal exhibits on its surface one of the most remarkable accumulations of the fossil remains of the vegetation of the coal period ever exposed to view.* There are upwards of seventy trunks of trees, apparently dicotyledonous, broken off close to the root, and several of them are more than 8 feet in circumference; the prostrate trunks lying across each other in every direction. One of these measured 30 feet, another 15 feet in length, and several others a few feet less. They are invariably flattened to the thickness of from one to two inches, yet both upper and under side preserve a distinct trace of bark. The stumps, also, exhibit a distinct ring of bark, which, as usual, has become a bright coal, with a crystalline fracture; while the interior or woody part is a dead-looking coal, nearly approaching to cannel coal.

These stumps seldom rise much above the surface. Many of them are surrounded by a circular ridge, formed by the materials of the bed accumulating round them. In a few cases the place of a trunk is marked by a circular depression in the coal, the trunk having been probably removed with the overlying fire clay. In some of the stumps the thick diverging roots may be traced by clearing off the coal, nearly a yard from the circle of bark; and I was enabled to clear away from one of the trees the surrounding coal and shale, down to the substratum of fire clay; but no trace of stems or of the long radicles or leaves of *stigmaries* were found, either in the shale or fire clay. Impressions, more or less distinct, of stems of *Stigmaria ficoides*, are found in the shale in some parts of the deposit; but in no case, so far as we could discover, could any connection be traced with the adjacent trunks. Many spots between the trunks are almost covered with impressions of *Calamites*, two or three distinct species of which may be recognised, in some places forming groups of six or eight square feet. The stems of *Lepidodendra* with the impressions of the scales finely preserved, and *Lepidostrobus*, are also scattered in profusion over the surface; and mingled with these vegetable remains are occasionally found the teeth and other fragments of fishes. There are also found ring-shaped bodies, sometimes in pairs, which appear to me to be identical with the bodies figured in Plates 8 and 10 of Dr. Hibbert's Paper on the Fresh-water Limestone of Burdie House, in the 10th Vol. of the Trans. of Roy. Soc. of Edinburgh, p. 169.; and said to be the scales of *Megalichthys Hibberti*, which have lost their external lamellar structure.

Not the least curious circumstance, in connection with this deposit, is, that although the whole is not more than 12 feet in thickness, there are at least three distinct beds of coal, each of which exhibits on its surface the remains of an ancient forest of

* See diagram, p. 43.

large trees. A reference to the annexed section will show the position of these beds. The upper growth of vegetation is on a stratum of coal 10 inches thick, under which is a band of clay 2 inches thick; this lies undisturbed on the south end of the platform, but is removed from a few yards south of the centre to the northern extremity; and the second bed is there exposed, covered, like the upper, with trunks, &c. The coal is here about 2 feet thick, and rests on a band consisting of 4 inches of shale and 8 of fire-clay. Five feet below this grew the third forest; the surface, where the upper beds have been removed, exhibiting similar large stumps of trees, *Lepidodendra*, *Calamites*, &c.



Section of the fault and fossil trees in the Parkfield Colliery.

At Millfields colliery, one mile to the east, the same beds are found at a depth of 126 yards.

In several points of view, the deposit at Parkfield must be interesting to geologists. The position of the trees, in each bed of coal, seems almost to preclude all doubt of their having grown and perished on the spot where their remains are now found, and the roots are apparently fixed in the coal and shale, which was the original humus in which they grew.

As is generally the case with stems found prostrate in coal, these stems are flattened. The woody tissue perished before the superincumbent strata were deposited, leaving nothing but a tube of bark, which readily yielded to pressure. This is well seen in a specimen, in which the bark is preserved, as well on the under as on the upper side, while no woody tissue lies between; the liber, or inner side of the bark, from each side of the stem being crushed into contact. It is from this cause that the ligneous structure of coal fossils is so rarely preserved. The large trunks, in nearly all cases, have been reduced to mere cylinders of bark, probably by a process similar to that pointed out by Mr. Hawkshaw, and now to be seen in tropical forests, where, by a combination of causes, a large tree is reduced, in a few months, to a hollow tube which yields to the slightest pressure. In this state, if a stem fall, it is flattened; if it remain erect, the interior becomes filled up with the ferruginous or carbonaceous materials of the surrounding bed, which occupy the place of the rings of woody tissue.

Whatever may be our success in discovering the botanical character of these trees by microscopic aid, the evidence is not slight that they were most of them allied to Coniferae; and few who have carefully compared the *Lepidodendra* with the leaf-bearing stems of the *yew*, *spruce-fir*, or various species of *pine*, can have much doubt of the fossil plants being allied to these recent ones.

In conclusion, I may observe that I have been induced to make this communication to the Geological Society, because it is one of the very rare instances of the surface of a bed of coal being exposed over a large area. It is very probable that similar interest-

ing glimpses of the vegetation of a former world would be frequently seen, if, instead of working in the dark and cutting down the edges of the strata, we could remove at once the upper covering, as at Parkfield, and expose to the day the face of coal on which the ancient forests grew.

4. *Some Account of a FOSSIL TREE found in the Coal Grit near Darlaston, South Staffordshire.* By JOHN S. DAWES, Esq. F.G.S.

WITHIN the last few days (Jan. 1844), an exceedingly well-preserved and extraordinary specimen of a fossil tree has been discovered in a stone quarry near the town of Darlaston. The rock, which also contains Calamites and other drifted coal fossils, is the White Grit, which overlies the thin carboniferous measures, on the north-eastern side of the South Staffordshire coal field; the fossil, 39 feet in length, lies in the ripple-marked stone, at a depth of 16 yards from the surface, the nearest bed of coal being ten yards below it. The root end is towards the deep, and in a westerly direction. Its angle of inclination is about 6° , which also corresponds with the dip of the strata; distinct traces of four branches may be observed upon the stem, three of which, when it was found, were still attached, and apparently in the position in which they grew, but one of them was moved aside from its original direction. They extended in length from 6 to 8 or 9 feet, having a diameter varying from 6 to about 4 inches, and the upper one yet remains attached, and shows a remarkable uniformity in its thickness. The others were in part broken to pieces, and some of them lost before I was aware of the specimen being in the quarry; but I understand that each appeared to terminate abruptly, having a small portion of coaly matter adhering to the end. There is also some appearance of a fifth branch projecting in a contrary direction, but possibly this may belong to another specimen, still imbedded lower in the quarry. The following are the dimensions as nearly as can be ascertained while it remains *in situ*:—diameters of stem, at the lowest part, 14 inches and 6 inches; distance to the first branch 11 feet 6 inches; diameters at this point 16 inches and 6 inches; distance from this to the second branch 5 feet 6 inches; diameters 18 inches and 6 inches; distance to third knot 7 feet; diameters 16 inches and 12 inches; distance again to the upper branch 6 feet 6 inches; diameters 17 inches and 10 inches. From this part to the top, the distance is 8 feet 6 inches, where the breadth is suddenly contracted to less than 8 inches, and immediately beyond the fossil is converted into a thin narrow layer of coal, showing in a remarkable manner a gradual change from the stony mineral into that substance. This upper part, which has been traced about 18 inches further, still continues to penetrate the solid rock, and the lower end has been uncovered to the further

extent of 3 feet 9 inches, where this part also is found to enter the side of the quarry; so that the whole length of this splendid fossil, so far as it is yet traced, is upwards of 44 feet, and its greatest breadth is not more than 20 inches. At this point it has evidently been the most compressed, being here only about 4 inches in depth; but from the second branch to within 3 or 4 feet of the top, the tree maintains, in a remarkable manner, almost its original proportions. It will at first sight appear extraordinary that the breadth within 6 feet of the lower end should not exceed 12 inches; this however, without doubt, arises from the greater degree of carbonisation which is evident at this part, and indeed marks of the original exterior may be traced upon the adjoining stone to the extent of 19 inches. The substance of the tree, though not silicified, is hard and fine-grained, differing entirely in appearance from the rock which surrounds it, having become more highly impregnated with iron, to which probably its present state of preservation is to be attributed. It is evident that the mineralising process must have commenced prior to any extensive decay, for in all probability the structure has been well preserved. Microscopic sections, which I have not yet been enabled to obtain, will of course afford the best evidence as to its affinity with other fossils, and with recent wood; but I may observe that there is an appearance of concentric rings, and, moreover, a large development of pith, but differing probably from every other described fossil stem. The bark, in general, has been converted into a thin layer of bright coal, which becomes fractured, and in part separates, on removing the overlying rock; but no trace of leaf-scars or punctures have yet been detected either upon the stem or its branches; the decorticated exterior, particularly of the latter, which presents a smooth surface with broad irregular striæ, having a waved and somewhat twisted appearance. These branches show indications of cicatrices, as though other lesser ones had formerly been attached to them; and it may be remarked that small branches exhibiting this peculiar exterior have repeatedly been met with in the South Staffordshire coal district. I may mention, in conclusion, that I have obtained some excellent sections of the wood, which show that the structure is remarkably perfect, and prove the tree to have been coniferous.

5. *On the TRAP-ROCK of BLEADON-HILL, in Somersetshire.* By the Rev. D. WILLIAMS, F. G. S.

SINCE the author's last communication on this subject*, the completion of the Railway cutting through the western point of Bleadon Hill has disclosed several new and remarkable facts; and these have so materially changed his views respecting the origin

* Geological Transactions, 2d ser. vol. vi. p. 561.

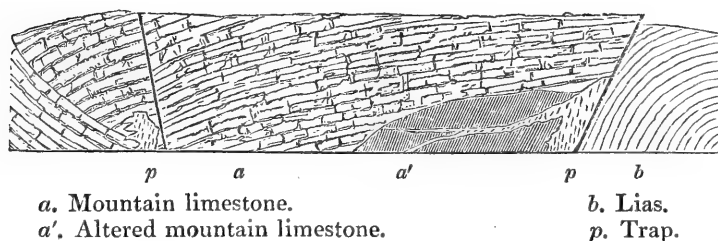
of trap and other rocks, that he has been led to draw up a supplement to his former papers.

The Mountain Limestone of Bleadon Hill and that of Uphill have been disconnected by two great downcast faults since the lias was deposited, that on the Bleadon side ranging E. by N. and W. by S., and that on the Uphill side N. E. and S. W. In the space between them, which is about a quarter of a mile broad, the surface consists of lias and new red sandstone.

In the cutting the Bleadon fault is finely exposed, and its southern side presents a great slickenside wall of limestone and trap, which dips to the south at an angle of 70° . On the northern side of the fault, the lias is seen, curiously faulted, to some little distance; it then dips considerably towards the fault, the inclination increasing, and the beds at last going down with the fault, the lias inclining towards it at an angle of 45° . The lias, where abutting against the trap, has no appearance of having been altered by it.

SECTION I.

WESTERN SIDE OF RAILWAY.



On the western side of the Railway, not far from its northern end, an insulated mass of Mountain limestone is seen standing several feet in advance of the vertical cutting. Though much altered and deprived of the usual planes of bedding, it may readily be identified by its nodules of chert and crinoidal stems and plates.

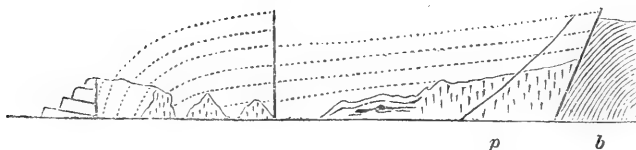
Little doubt can be entertained that it was once the continuation of four thick beds, which rest on its southern flank, and in the process of quarrying have separated from its surface. Nearly half the base of this insulated mass of limestone has been removed, and replaced by trap, the surface of contact between the two being very rough and unequal; and a foot or two further towards the north there rises from beneath this altered limestone a mass of trap, 9 feet thick at its base, which, as it ascends, gradually tapers, and at the height of from 20 to 25 feet is reduced to a thin string, or enters into joints of the limestone. The limestone is highly altered, and the limestone walls of the joint are singularly rough and rugged throughout. The limestone is traversed by a long, narrow, irregular crack, in which are found thin seams and plates of trap and trappan matter.

Fifty-four feet to the south of the first mass of trap, another irregular mass of the same rock shows itself, and ascends through

the beds of limestone diagonally, overhanging on its southern side. Close to the northern side of this mass, a well-defined joint cuts the limestone from its base to its summit, so that between this joint and the trap there is a thin strip of limestone which, on its side next the trap, is very irregularly indented.

SECTION II.

EASTERN SIDE.



Proceeding next to the eastern side of the cutting, and beginning at its northern end, the lias (*b*) is first seen, dipping towards the wall of limestone and trap. On the opposite side of the fault, and at the base of the limestone is seen a mass of trap (*p*'), the upper surface of which runs nearly parallel to the calcareous beds above it. Further southward, however, that surface becomes irregular, and descends more rapidly than the beds of limestone; and near its southern end the mass of trap descends at an acute angle below the level of the cuttings. Further southward, a second mass of trap appears, and at a short distance a third, and then finally a fourth.

The author next describes the alterations produced in the limestone on the eastern side of the cutting.

At the northern fault, the face of the wall of limestone that lies above the trap is eroded in places into broad shallow cavities filled with trap and trappean matter, the trap having generally selected the joints and fissures in the limestone, and being therefore variable and unequal in thickness here, as on the other side of the cutting.

Three of the beds of limestone have been affected by the intrusion of the trap: the lowest varies much in thickness, and is reduced where the trap appears. The second bed is affected and sometimes cut off by the trap, and sometimes becomes blended with the superior bed of limestone, and towards the fault dips down towards it. This latter bed abuts against the fourth mass of trap (towards the south), the contact being rough and rugged.

The curvilinear fault above noticed has shifted the beds of limestone. On the southern side of this fault, we find resting on the southern flank of the fourth mound of trap a mass of altered limestone, which, as it approaches the summit of the trap, tapers upwards and disappears. The surface of this wedge of limestone, where in contact with the trap, presents the same pitted and irregularly eroded appearance which has been before noticed in limestone similarly situated.

Near the middle of the first or northernmost mass of trap, and entirely insulated by it, a patch of limestone was found. This was in some parts attenuated to a thin lamina, and in others terminated in long and slender strings. It was imbedded in the trap to the depth of about a foot.

As to the mineralogical character of the Bleadon trap, it is of a reddish-brown, or greenish-grey colour, and is usually traversed by veins and strings of calcareous spar, which often pass into yellow crystalline limestone. It contains, in abundance, small spherical kernels of calcareous matter, which are usually coated by red oxide of iron. Less frequently it contains steatite, and still more rarely glassy felspar. The rock is rather tough than hard, and decomposes so freely, that specimens of it adhering to the limestone are not readily procured.

The altered limestone has lost its original blue tint, and, in proportion to the alteration it has undergone, has become, first, light-red; secondly, buff; thirdly, bright deep yellow; and lastly, deep-red. In all its bright and deep-red stages, it is crystallised into obtuse rhomboids, like calcareous spar, into which it passes. All the above gradations are frequently seen in the same bed. From its original state of extraordinary hardness the altered limestone has become very crisp and brittle.

The distance from the trap to which the alteration of the limestone extends, is from 5 to 25 feet.

The author is of opinion that the principal shifts, faults, and dislocations which are observable in the limestone beds at Bleadon, took place prior to the intrusion of the trap, and are not attributable to that intrusion. In two instances, however, joints are observable which run through the limestone and the trap continuously; though they are more obscure in the latter than in the limestone.

Reasoning on the preceding facts, the author states his inability to account for them, on the supposition that the trap was injected or forcibly intruded into its present position.

Referring to the southernmost mass of trap, visible on the west side of the cutting, it will be seen that the outlines of the limestone on the southern and northern margins of the trap do not correspond; so that it cannot be supposed that the beds have been parted asunder; nor do the beds adjacent announce anything of the sort. If it be supposed that the limestone, which filled the space now occupied by the trap, has been forcibly removed, the overlying beds bear no evidence of any displacement at all; the deep acute-angular indentations of the mass would be very unfavourable to such removal; and there is no mass of limestone visible above or elsewhere, which in any way agrees in form with the mass of trap.

If it be supposed that the trap was injected into some previously existing cavities, into the hollows and inequalities of which it became moulded, that would not account for the extent to which

alteration is manifested in all the rocks around, nor for their unequally altered condition, amounting in some instances to indications of active fusion; nor will it explain the occasional spots and irregular forms of trap which are insulated in the limestone.

Referring to the patch of limestone entangled in the northernmost mass of trap, on the eastern side of the cutting, the author states his conviction that no fragment of a similar limestone, of like forms and dimension to that in question, could be separated from its parent rock by mechanical agency of any kind, unless by the most elaborate design; so thin are the plates and so slender are the strings of this limestone patch, which is insulated in the trap.

The explanation of these phenomena which the author has to offer is, that the lime-rocks have been reduced *in situ* by tranquil fusion, and have been converted by subsequent cooling and crystallising into the trap which now replaces them, occupying the very position before occupied by the limestone.

The patch of limestone insulated in the trap, the author conceives to have been a calcareous fragment, which had escaped entire fusion; and he can imagine no process in nature to account for the spots of trap, insulated in the limestone, except that of intense heat.

The author notices that there is nowhere to be met with, in the proximity of the trap, any extraneous matter which might be referred to the action of liquid lava on the limestone; but it is all limestone, or all trap. What, he asks, can have befallen the portions of the limestone beds which have disappeared, unless they have been melted up, and converted into trap?

The author does not mean to question the fact that, in certain instances, trap and other volcanic rocks have been forcibly introduced among sedimentary and other rocks; but only wishes to show that, in other instances, there is evidence that the presence of trap is attributable to the reduction of pre-existing rocks by volcanic agency.

These views led the author to arrange Volcanic Products under two heads, the immediate and the intermediate; the former consisting of such products as have been fused down and crystallized *in situ*, or have been ejected from submarine vomitories, or subaerial craters; the latter, of such rocks as have been acted upon more or less extensively, and only partially reduced by active fusion, and were therefore in different states of reduction when the temperature was finally withdrawn. In the former he comprises granite, porphyry, the several varieties of trap, tufaceous ash, breccia, grit, flinty chlorite, talcose and clay slates; in the latter head he comprises gneiss and mica-, chlorite-, and hornblende-schist.

JANUARY 17. 1844.

Eaton Hodgkinson, Esq., F.R.S., of Manchester, and Lieutenant-Colonel Sabine, R.A., F.R.S., were elected Fellows of this Society.

The following communications were read :—

1. *On certain CRUSTACEANS found at Atherfield by Dr. Fitton.* By T. BELL, Esq., F. R. S., Professor of Zoology in King's College, London.

[The notice of this paper in the "Proceedings" is postponed.]

2. *On the Occurrence of PHOSPHORITE in Estremadura.* By CHARLES DAUBENY, M.D., F.R.S., Professor of Chemistry in the University of Oxford; and Captain WIDDRINGTON, R. N., F.R.S.

A STATEMENT having frequently been made by mineralogical writers, that there exists in the Spanish province of Estremadura an extensive formation of Phosphate of Lime, it was considered by some leading Members of the Royal Agricultural Society of England an object of importance to learn the truth of these statements; and the authors were, therefore, commissioned to ascertain where and under what circumstances the substance in question was found; what facilities existed in the country for procuring it and conveying it to the coast; and whether, if used as a manure, it was of a nature to serve as a substitute for the bone earth, now employed extensively in husbandry.

The original authority for the statement, that there occurs in Estremadura a certain mineral which, when thrown upon live coals, becomes phosphorescent, was found to be William Bowles, who, in his introduction * to the Natural History and Physical Geography of Spain (2d edit. 4to. Madrid, 1782, p. 6.), relates, that, at the foot of a range of mountains running E. and W., and called the Mountains of Guadalupe, and in the immediate vicinity of a place called Logrosan, the royal road is traversed obliquely, from N. to S., by a *vein* of Phosphoric stone. This stone was said to be of a pale colour, and without taste; and, when sprinkled upon live coals, to emit a blue flame, but no smell.

Proust, the distinguished chemist, in a letter to the French chemist, D'Arcet, dated Madrid, 12th of September, 1787 (which letter is published in the *Journal de Physique* for April, 1788), communicates the important information, that the mineral in question, of which he had received specimens from an apothecary at Madrid, gives off phosphorus when heated with charcoal in a retort. He quotes from the work of Bowles the passage above referred to; states that he has not been able to visit the spot where the mineral is found; and, from information which he has re-

* 1st edit. 4to. Madrid, 1775. — French translation of do. 8vo. Paris, 1776. — 2d edit. of the original, 4to., Madrid, 1782. — Italian trans. of 2d edit., with notes, by Don J. N. D'Azara, 2 vols. 4to. Parma, 1783.

ceived, gives the following account, varying from that of Bowles in several particulars.

"This stone is found near Logrosan, a village in the jurisdiction of Truxillo, in the province of Estremadura. It occurs, *not in veins, but forms entire hills*. The houses and the walled enclosures of the fields are built of it."

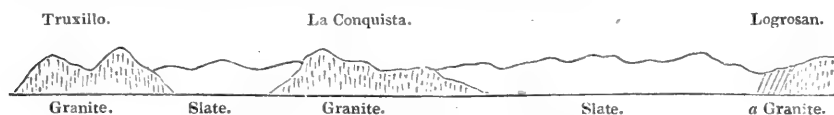
On reaching Madrid, the authors were informed by the head of the Department of Mines, that the mineral formed a vein in granite.

The authors, after this introductory notice, then proceed to give an account of their researches.

Between the tertiary table-land of the two Castiles, and the descent of the south-eastern escarpment of the Sierra Morena, as you enter on the plains of Andalusia, a district of country intervenes, over a large portion of which a formation of clay-slate, with occasional masses of quartzite, forms the fundamental rock. In proceeding from Madrid, it was to the south of Talavera de la Reyna, at the village of Calzada de Oropesa, that this formation first appeared. In the steep ravine through which the Tagus flows near the broken bridge of Almaraz, dark blue slate appears in vertical strata. Puerto di Miravete is the culminating point of this formation, from which a vast table-land is seen intersected by low flat-topped ridges, rising from three to four hundred feet above the plain, and studded over with conical hills. The above ridges, according to Le Play, are occasioned by beds of quartz; and this statement agrees with the observations made by the authors above Almaden. The quartzite is either compact, granular, or brecciated, or constitutes a fine-grained sandstone. The conical hills consist of granite, which has forced its way through the slate. Examples of this occur at Truxillo, and a league onwards on the road to Logrosan. Then slate re-appears, then granite for the space of a mile; then slate again; which continues to Logrosan. To the south of that village, granite again appears, rising to the height of four or five hundred feet. With this exception, all the rocks around Logrosan, and thence as far as the Monastery of Guadalupe, consist of the clay-slate and quartzite.

The granite is much decomposed, and divides into blocks, which strongly resemble Cyclopean walls.

Near Logrosan the following section is seen :—



a. Phosphorite beds of Logrosan. *

* The slaty beds are grouped according to the following order :—

1. Dark blue, homogeneous, and excessively hard and compact fissile slate, intersected by veins of quartz. This is the common building-stone at Logrosan.
2. A soft and talcose slate.
3. A micaceous slate.
4. Alternating layers of talc and granular quartz.
5. Brecciated and slaty beds.

The authors could not learn that, in the neighbourhood of Logrosan, the slate contains any fossils, although, according to Le Play, it contains near Almaden an abundance of *Spirifer attenuatus* and of a *Terebratula*; and, according to the miners of Almaden, Trilobites had been found in it. These slates are referred to the Silurian period.

Between the granite and the slate there occurs a more crystalline rock, resembling mica slate, and said by Le Play to contain chialstolite. The authors met with this rock between Almaden and Cordova, near the granite of Viso.

Logrosan is a considerable village, about seven Spanish leagues S. E. of Truxillo. In the neighbourhood of the village the surface of the slate is undulated, the difference of level between the heights and depressions being about fifty feet. It is in the clay-slate that the Phosphorite occurs. See the section in the last page.

It may be traced on the surface or immediately beneath the soil, running in the direction* of the rocks themselves, that is, from N. N. E. to S. S. W., for the distance of nearly two miles. It terminates southwards not far from the base, and a little to the east of the granite hill. The summit of the hill and its north-eastern declivity consist of granite; but the side nearest the phosphorite consists of clay-slate. At this point the phosphorite is 16 feet wide, and extends to an unknown depth. It has been penetrated to the depth of only 10 feet.

As was noticed by Bowles, the seam crosses the road leading from Logrosan to Guadaloupe, and it forms an inconvenient rise in the road where it crosses. To level this, the seam had been broken down, and its fragments had been used to repair the neighbouring walls, and in the construction of a fence that separates the road from an olive plantation, and it seemed here to be very little altered by exposure to the weather. The rock is a compact clay-slate, of indistinct slaty cleavage, and is disposed in beds inclining from the granite, but nearly vertical. The seam of phosphorite is only 7 feet thick, and it is only the middle portion, to the width of 3 feet, that is in a state of purity. The rest consists of phosphorite, alternating with layers of hornstone, containing iron and a trace of phosphate of lime. Other small seams of phosphorite proceed obliquely from the main seam, and penetrate the clay-slate to some distance.

The mineral is disposed in zones, after the manner of agate, round centres of crystallisation, each zone being an assemblage of converging crystalline spiculæ. Pure white zones of the mineral are often separated, one from the other, by their dark-brown layers, tinged with oxide of iron. Between contiguous zones, having different centres, void spaces often occur, and when this is the case, the surface of the mineral next the cavity is mammillary. Crystals of quartz also occasionally line these cavities.

From the point where it crosses the road, the deposit was traced

* Le Play speaks of the Phosphorite as intersecting the clay-slate.

in a S. S. W. direction, across the olive plantation, and down a gentle declivity, until it was lost sight of.

The following is the mean of two analyses that were made of the purest specimens of phosphorite that could be selected :—

Silica	-	-	1.70
Peroxide of iron	-	-	3.15
Fluoride of calcium	-	-	14.00
Phosphate of lime	-	-	81.15
			<hr/>
			100.00
			<hr/>

The authors take occasion to remark that, in seven varieties of Apatite which were analysed by Gustavus Rose, from 4.59 to 7.69 of fluoride of calcium were detected ; and they call the attention of chemists to the association of the elements of Fluorine and Phosphorus which takes place in the Phosphorite of Estremadura, as it does in recent and fossil bones and teeth.

The only practicable route at present for conveying this mineral to the coast is by a six-days' journey in bullock cars, or on the backs of mules, to Seville.

3. *Notes on the CRETACEOUS STRATA of NEW JERSEY, and other Parts of the United States bordering the Atlantic.* By C. LYELL, Esq., M.A., F.R.S.

THE cretaceous and tertiary deposits of America, which intervene between the Alleghany mountains and the Atlantic, bear a great resemblance in mineral character to the sandy and argillaceous portion of the formations of the same age in the south-east of England. If all the white chalk, with its flints, together with the cherty beds of the green sand, were omitted, the remaining cretaceous strata in our island would consist of loose incoherent sand with green particles, red and highly ferruginous sandstones, white sands, and (in some places) beds of lignite ; the overlying tertiary deposits, consisting of marls, clays, and variously coloured sands occasionally exhibiting green particles, like those of the green sand below the chalk ; and as in the bottom of the London basin near Reading. Such, for the most part, is the succession of the beds in New Jersey ; and, further south, in Maryland and Virginia, the Eocene strata are often as full of green particles as the cretaceous, so that they are only distinguishable by their fossils and relative position. Even the Miocene strata are sometimes, as in Virginia, of a blueish-green colour, and contain green particles of a similar kind. This fact alone of the identity in lithological character of the secondary and tertiary strata of the United States is calculated to put us on our guard against inferring that the green and ferruginous sands of New Jersey correspond in age to the lower rather than the upper part of the European cretaceous

system. It is scarcely possible, on recognising so many of the common organic forms which are familiar to us in connection with the cretaceous rocks on this side of the Atlantic, and seeing them occur in beds which have the exact mineral type of the beds below the Gault, not to feel a strong inclination to regard them as the equivalents of our greensand, and to consider the white chalk as wanting. But when we dismiss from our minds, as we ought to do, the bias derived from the consideration of the mineral aspect of the beds, and compare the fossils of New Jersey with those derived from the European chalk, we find the agreement upon the whole to be far greater with the beds occurring in Europe above the Gault, than with those which are found below it. We are indebted to Dr. Morton for having pointed out, in 1834, the general agreement of the organic remains of the American and European cretaceous fossils, while, and at the same time, he and Mr. Conrad correctly observed that almost all the species were different. He divided the strata of New Jersey into the ferruginous sand, which he compared to our green sand formation, and the calcareous strata, which he identified with the white chalk of Europe. Prof. H. D. Rogers has since divided the New Jersey cretaceous beds into five formations, which are very useful, topographically considered, but which may be overlooked in the present paper, because only two of them, namely, those alluded to by Dr. Morton, have as yet yielded a sufficient number of fossils to entitle them to rank as palæontologically distinct.

In an excursion which I made in New Jersey, in September, 1841, in company with Mr. Conrad, we went first to Bristol, on the Delaware, next, by Bordentown, to New Egypt, and returned by the Timber Creek, recrossing the Delaware at Camden. On this occasion I had an opportunity of examining the strata of both these formations, and I collected nearly all the fossil species described by Dr. Morton, together with some few additional ones. I shall now, therefore, briefly notice these two deposits and their fossils, and consider them in reference to their European equivalents.

Although in this part of New Jersey there is no white chalk with flints, so characteristic of rocks of the same age in Europe, it is still impossible to glance at the fossils and not be convinced that Dr. Morton was right, as before hinted, when in 1834 he referred the New Jersey deposits to the European Cretaceous era, and remarked that the American species of shells were nearly all new or distinct from those before described, and yet very analogous to those of the chalk already known. Of the two well-marked subdivisions of the Cretaceous system the lower consists in great part of green sand and green marl, and was supposed by Dr. Morton, as already mentioned, to be the equivalent of the English green sand, while an upper or calcareous rock, composed chiefly of a soft straw-coloured limestone with corals, was thought to correspond with the white chalk of Europe. But after carefully comparing my collection, comprising about sixty species of shells, besides

many corals and other remains, I have arrived at the conclusion that the whole of the New Jersey series agrees in its chronological relations with the European white chalk, or, to speak more precisely, with the formations ranging from the Gault to the Maestricht beds inclusive. Among the shells, in determining which I have been assisted by Professor E. Forbes, not more than five out of sixty seem to be quite identical with European species; but several others approach very near to, and may be the same as Europeans; and at least fifteen may be regarded as good geographical representations of well-known chalk fossils belonging for the most part to beds above the Gault in Europe. There are a few very peculiar forms among the American testacea, such as *Terebratula Sayii* Morton; and I found among the univalves a *Bulla*, but casts of the genus had previously been mentioned by Dr. Morton, and although not yet known in the European chalk a species occurs on the Continent in beds of the Jurassic system.

In the upper or straw-coloured limestones, I found on the banks of the Timber Creek, twelve miles south-east of Philadelphia, six species of corals* and several echinoderms, chiefly allied to *upper* cretaceous forms. The same calcareous formation also abounds in Foraminifera characteristic of the chalk, comprising, among others, the genera *Cristellaria*, *Rotalina*, and *Nodosaria*. Besides the shells there are also several remains of fishes, and of the series obtained by myself all those referred to the genus *Lamna* resembled species occurring in our chalk. They have been examined for me by Sir P. Egerton. One of them seems to approach very closely to *Lamna appendiculata*, and another comes very near to *Galeus pristodontus*; and indeed, if we may judge by so few specimens, seem identical. These are fossils of our upper chalk in Europe. There are also several forms of *Carcharias* not very unlike some tertiary species given me from the New Jersey chalk, several of which are figured by Dr. Morton; I will not dwell upon these however, since in Europe also there are many of the cretaceous Squalidæ which can scarcely, when the teeth alone are considered, be distinguished specifically from tertiary fossils.

There are three Saurian vertebræ in the New Jersey green sand in the collection of the Geological Society, which I have submitted to Mr. Owen's inspection. One of these, from the green sand of Mullica Hill, is the anterior dorsal vertebra of the Mosasaurus. Another is the posterior cervical vertebra of a Pliosaurus, a genus which Mr. Owen has constituted to include a portion of the Plesiosaurs, and which approach still more nearly to the true Saurians. The vertebra in question resembles very closely that of *Pliosaurus brachydeirus* of the Kimmeridge clay. Until very lately, the Plesiosaurian type was not known higher in the series than in the Oolites; but it has now been shown to ascend to the chalk of Europe, so that its occurrence in the New Jersey strata is in strict accordance with European analogies. The third specimen (pre-

* These have been described by Mr. Lonsdale, and the description and figures will be given at the end of the present paper.

sented, I believe, by Professor H. D. Rogers) is labelled, "Woodstown, New Jersey;" a locality where those beds occur to which the great mass of shells before alluded to belong. It is a vertebra, penetrated by the green particles of the sand. Mr. Owen refers this to the dorsal vertebra of a crocodile of his *Procœlian* division, or those which, like the recent crocodiles, have the concavity in the forepart, and the convexity behind. This fact is important, as hitherto the *Procœlian* crocodiles in Europe have not been found in beds older than the eocene.

In concluding these remarks on the ferruginous and green sand formation of New Jersey, I may observe that the identification of four or five species out of sixty fossil shells with European cretaceous fossils would give an agreement of about seven per cent., which is by no means a small amount of correspondence, when we consider that the part of the United States above alluded to is distant between 3000 and 4000 miles from the chalk of Central and Northern Europe, and that there is more than 10° difference in the latitudes of the two districts compared, on the opposite sides of the Atlantic. It may doubtless be true, that the influence of temperature during the Cretaceous period was less powerful in limiting the range of species than it is now; and that the same forms prevailed more uniformly from India to Sweden, than they do at present. Nevertheless, the cretaceous fossils of Northern and Southern Europe differ sufficiently to show that the climate had then no small influence in causing distinct geographical provinces of species; and it seems natural that those species which are very abundant in Europe, such as *Belemnites mucronatus*, or those which have a great vertical range, such as *Pecten quinque-costatus*, should be the fossils found, if any, to recur in a distant part of the globe.

In the next place I proceed to give some account of the upper fossiliferous division of the New Jersey cretaceous deposit, which is for the most part arenaceous, but contains, in many places, layers of limestone and calcareous sand, with corals slightly aggregated together. It has been traced by Mr. Rogers to a distance of about 60 miles in a north-east and south-west direction, from Prosper Town to near Salem, having rarely a breadth of half a mile, and the thickness being from 6 to 20 feet. Its importance is derived, geologically speaking, from its fossils, and, in an economical point of view, from its affording the only lime procurable in this district. I saw the formation in question, on the banks of Timber Creek, a stream which flows into the Delaware, three miles below Philadelphia. The principal locality is twelve miles S. E. of Philadelphia, about a mile and a half south of the village of White Horse, in Gloucester County, New Jersey. Here a bed of soft calcareous stone, about 20 feet thick, is seen made up, in great part, of corals of the genera *Eschara*, *Escharina*, *Cellepora*, *Tubulipora*, and others*, together with the remains of echinoderms, such as *Cidaris* and *Spatangus*. It contains also some shells, as *Scalaria annu-*

* See the description of these corals by Mr. Lonsdale, in the Appendix.

lata, *Gastrochæna*, and *Teredo*, the whole indicating the sandy bottom of a shallow sea. I was so strongly reminded of the coralline crag of Sudbourn, and other places in Suffolk, when examining this rock, that I had some difficulty at first in persuading myself that it was not a tertiary deposit. It is, in a great part, a mass of white calcareous sand, more or less aggregated together, and the upper surface has been irregularly scooped out and rendered undulating, and is covered with a newer deposit of red clay and gravel, without fossils, the surface of which is even and level. This white sand and limestone pass downwards into light-green and ferruginous sand, with quartzose grains.

Near Hornerstown, I saw, on a branch of the Timber Creek, to which Mr. Conrad conducted me, a bed of this coralline aggregate, 8 feet thick, resting on the green sand or lower deposit before mentioned, with its characteristic fossils.

We have now to consider whether the calcareous or upper formation has been referred with propriety to the chalk. Mr. Forbes has examined the Echinoderms, and is of opinion that they are decidedly analogous to cretaceous forms. One of the species of *Spatangus* belongs to the same group as *S. subglobosus* of Goldfuss, a group which forms the genus *Holaster* of Agassiz, and which that naturalist regards as very characteristic of the upper part of the Cretaceous system.

One also of two species of *Cidaris* is allied to *C. vesiculosus*, and to other upper cretaceous species of Europe.

Dr. Morton had already observed, in regard to the corals, that some of the species resemble a Maestricht fossil, figured by Goldfuss; and the reader is referred to Mr. Lonsdale's comments on this subject in the Appendix.

The fossil called by Dr. Morton "*Belemnites ambiguus*," though probably not related to the Belemnite, is closely allied to a fossil which I have collected myself in the chalk of Sweden, associated with *Belemnites mucronatus*.

The last-mentioned, or upper of the two fossiliferous formations of New Jersey, has been called by Dr. Morton and Mr. Conrad the Medial Cretaceous, because there are others still higher in position in the Southern States, which they refer to the chalk period. One member of these, a white limestone, seen extensively on the Santee canal, and in other parts of South Carolina, as well as at Jacksonborough and Shell Bluff in Georgia, I have shown, in a former communication to the Society, to be Eocene tertiary. Another portion, called the Nummulite limestone of Alabama, I have not examined, and can therefore offer no opinion respecting it.

Upon the whole, the collection of fossils which I made in New Jersey confirms the principal conclusion to which Dr. Morton arrived, that there is a remarkable generic accordance between the fossil mollusca, corals, echinoderms, fish, and saurians of the cretaceous group, in New Jersey and in Europe. But the general analogy of the generic, and the identity of some specific, forms, which Mr. Forbes and Mr. Lonsdale have assisted me in comparing,

has led me to refer all the fossiliferous formations of New Jersey to that part of the European series which ranges from the Maestricht beds to the gault inclusive.

North Carolina.

Of the same age are certain strata in North Carolina, at a place called Lewis's Creek near South Washington, forty miles north of Wilmington, and 340 geographical miles south-west of New Jersey, where I found *Belemnites mucronatus*, *Ostrea vesicularis*, *O. subspatulata* (a remarkable and new species figured in the Appendix), *Cellepora tubulata*, and other fossils.

The association of *Cellepora tubulata*, which abounds in the upper cretaceous formation of New Jersey at Timber Creek with *Belemnites mucronatus* in this locality of South Carolina, is important, as helping to show the near relation of the coralline limestone of New Jersey to the green sand containing Belemnites.

Georgia.

Some fossils have been communicated to me by Dr. Cotting, from Georgia, which make it probable that there are cretaceous strata there, lower than those of New Jersey; as among them are a *Pholadomya* and an *Ammonite*; both of which Mr. Forbes finds to be closely allied to certain Neocomien species from Neuchâtel.

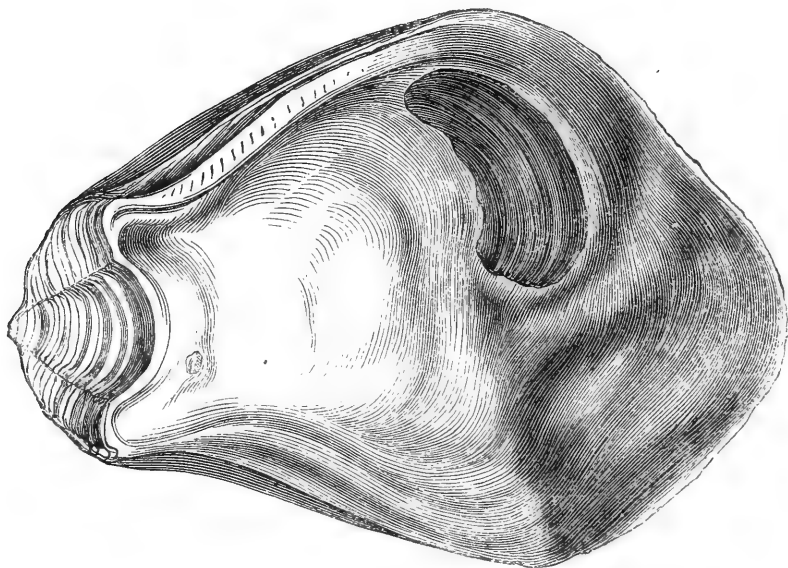
In the collection of Mr. Conrad, from Alabama, I saw a species of Hippurite, derived from the cretaceous strata of that State, which I believe is the only example of any fossil of the Rudist family derived from the cretaceous rocks of North America. It affords another point of analogy between the cretaceous fauna co-existing on opposite sides of the Atlantic.

It is interesting to find, as the result of this investigation, that the marine fauna, whether vertebrate or invertebrate, testaceous or zoophytic, was divided at the remote epoch under consideration, as it is now, into distinct geographical provinces, although the geologist may every where recognise the cretaceous type, whether in Europe or America (and I might add India). This peculiar type exhibits the preponderating influence of a vast combination of circumstances prevailing at one period throughout the globe, circumstances dependent on the state of the physical geography, climate, and organic world, in the period immediately preceding, together with a variety of other conditions.

APPENDIX I. — *On the FOSSIL SHELLS collected by Mr. LYELL from the Cretaceous Formations of New Jersey.*

1. *Description of New Species.* By Professor EDWARD FORBES.

MOST of the fossil shells (amounting to sixty species) collected in New Jersey during Mr. Lyell's excursion with Mr. Conrad have been already described in Dr. Morton's excellent work. The following, however, are new species:—



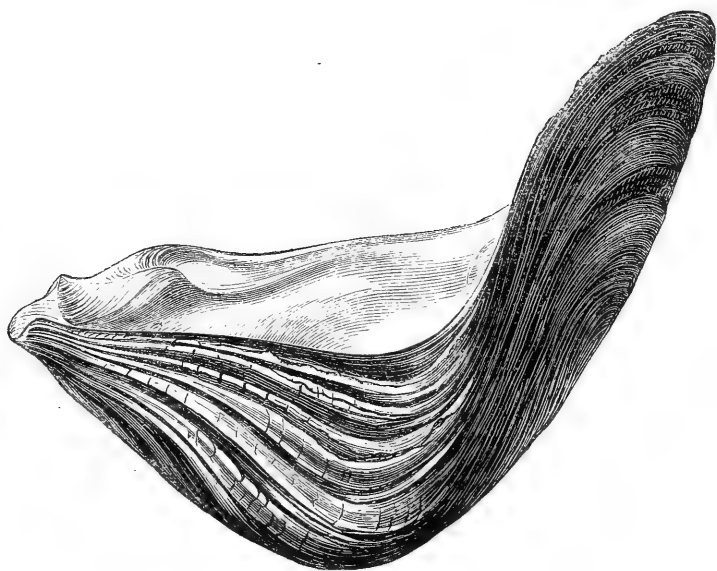
Ostrea subspatulata L. & S.

Interior of the Lower Valve.

[Two thirds the natural size.]

1. *OSTREA subspatulata*.* Lyell and Sowerby. Shell obovate; somewhat trapeziform; generally thick; higher than wide; narrower at the dorsal than at the ventral or basal end, which is turned downwards at an obtuse angle; somewhat foliaceous externally; muscular impression placed very near the base. Locality, Lewis's Creek, South Washington, North Carolina.

* *Ostrea obovata, spatulata*; valvâ inferiore, convexâ, arcuatâ, posticè crassissimâ; superiore subdepressâ.

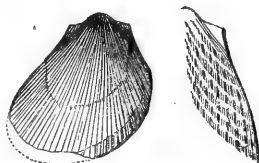


Ostrea subspatulata L. & S.

Side View of Lower Valve.

[Two thirds the natural size.]

2. *LIMA reticulata*. Lyell and Forbes. L. testâ ovatâ, obliquâ, inflatâ, tenui, longitudinaliter sulcatâ, sulcis reticulatis, numerosis. Habitat, Nov. Jersey.



Lima reticulata L. & F.

3. *TEREBRATULA Vanuxemiana*. Lyell and Forbes. T. testâ suborbiculare, valvis bicarinatis, longitudinaliter costatis, costis



Terebratula Vanuxemiana L. & F.

intermediis minoribus, valvâ superiori convexâ, areâ late triangulare, foramine magno, valvâ inferiori convexiusculâ, margine frontali subbisinuâtâ. Habitat, Nov. Jersey.

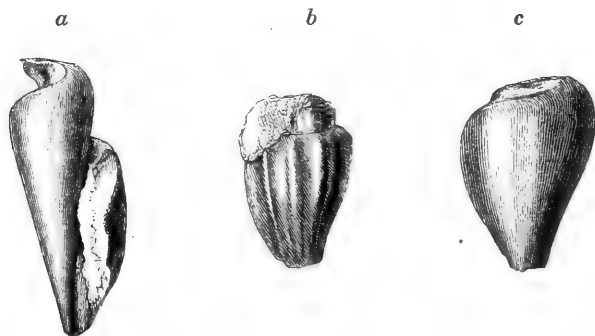


a. *Bulla Mortoni*.
b. *Natica*.
c. *Tornatella*.

4. *BULLA Mortoni* (a). (Cast.) Ovate, inflated, resembling in form *B. hydatis*, spire concealed, surface spirally furrowed, the furrows bearing traces of punctation.

5. *NATICA* (b). (Cast.) Of a small globular species with a deeply channelled suture, spirally sulcated, and obsoletely reticulated whorls and depressed spire. Locality, New Jersey.

6. *TORNATELLA* (c). (Cast.) Oblong, bearing traces of spiral striae; spire exserted, subdepressed; sides of body-whorl somewhat flattened; columella perforate; aperture lanceolate. Locality, New Jersey. Allied to *T. bullata* of Morton, which, however, is a much more ventricose species.



Casts of *Voluta*.

7. *VOLUTA*. (Casts.) a, Shell linear, lanceolate, whorls smooth. b, Shell ovate, whorls smooth. c, Shell ovate, whorls angular above, distant ribs.

Note. — The figures are all of the natural size, except the *Ostrea*, which is two-thirds in linear dimensions.

2. List of Species common to the American and European Cretaceous Systems.

Ostrea larva (*O. falcata* M.)
—— *vesicularis*
Gryphæa costata

Pecten quinque-costatus
Belemnites mucronatus

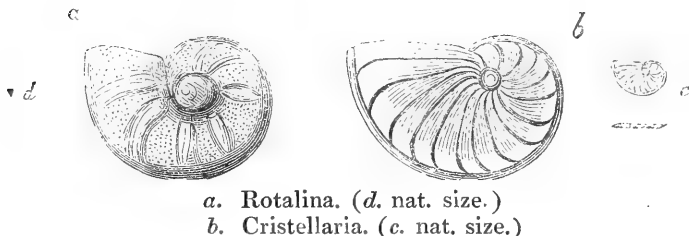
3. *List of New Jersey Species, Representatives of which occur in the European Cretaceous Beds.*

<i>New Jersey Species.</i>	<i>Probable representative European Species.</i>	
Spatangus n.s.	S. subglobosus	Geological locality in Europe.
Cidaris	C. vesiculosus	
Terebratula fragilis M.	T. biplicata	(Upper green sand)
——— floridana M.	T. Defranci et striatula	(Upper chalk)
Plicatula urticosa M.	P. inflata	(Chalk marl and upper green sand)
Inoceramus Barabini M.	I. Crippsii	(Chalk and green sand)
Cucullea vulgaris M.	?	
Trigonia thoracica M.	T. alæformis	(Green sand)
Pholadomya occidentalis M.	P. gigantea	(Lower green sand)
Phorus leprosus	P. canaliculatus	(Lower chalk)
Scalaria annulata	S. Dupiniana	(Gault)
Natica petrosa M.	N. excavata	(Gault)
Voluta	Several lower chalk species.	
Hamites arcuatus	?	
Ammonites placenta	A. clypeiformis	
Baculites ovatus	B. anceps.	

4. *List of Peculiar Forms found in the New Jersey Cretaceous Formations.*

Terebratula Sayii M.	Crassatella vadosa M.
Ostrea subspatulata n. s.	Venilia Conradi

Notice of the FORAMINIFERA. By Mr. LYELL.



a. Rotalina. (d. nat. size.)
b. Cristellaria. (c. nat. size.)

THE above are figures of the two genera of Foraminifera from the upper beds at Timber Creek, alluded to in the paper.

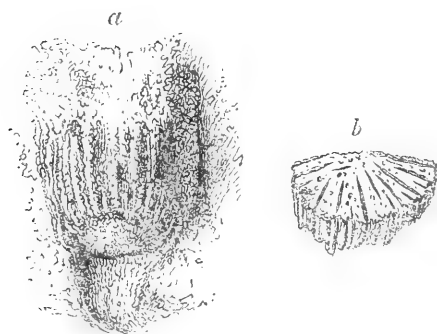
I am not aware that any attention has hitherto been paid to the fossil foraminifera of the American cretaceous strata, to which I find no allusion in Dr. Morton's works. They are very abundant in the coralline rock of Timber Creek. Mr. Forbes has examined some of them for me, and these belong to the genera Cristellaria, Rotalina, and Nodosaria. All these genera occur in the chalk of Europe. One of my American species of fossil Cristellaria is specifically identified by Mr. Forbes with *C. rotulata* of D'Orbigny, which occurs in England, France, and Germany, ranging from the upper greensand to the white chalk. It is another instance of species found most abundantly in Europe, recurring in the American chalk. There are two other species of the same genus at Timber Creek, one of them very large. There are two species of Nodosaria. The Rotalina, which is very abundant, is closely allied to a species of our chalk.

APPENDIX II.—*Account of SIX SPECIES OF POLYPARIA obtained from Timber Creek, New Jersey, and described by WILLIAM LONSDALE, Esq. F. G. S.*

THE following is a list of the species :—

1. *Montivaltia atlantica* *Lonsdale* (*Anthophyllum atlanticum* *Morton*).
2. *Idmonea contortilis* *Lonsdale*.
3. *Tubulipora Megæra* *Lonsdale*.
4. *Cellepora tubulata* *Lonsdale*.
5. *Escharina?* *sagena* *Lonsdale* (*Flustra sagena* *Morton*).
6. *Eschara digitata* *Morton*.

1. MONTIVALTIA ATLANTICA.



a. Nearly perfect specimen, exhibiting the lamelliferous or upper portion in its true position, and the inferior hollow cone.

b. Portion of the upper surface slightly worn down, to show the characters of the lamellæ.

Inversely conical; lower or non-lamelliferous portion nearly equal in length to the upper or lamelliferous; enveloping crust extending nearly to the superior termination of the cone; lamelliferous portion variable in form; lamellæ very numerous; centre, contorted plates terminating inferiorly in a distinct umbilicus or boss; superior termination of the cone nearly flat.

This coral is described by Dr. Morton under the name of *ANTHOPHYLLUM ATLANTICUM*. (*Silliman's Journ.* vol. xviii. pl. 1. f. 9, 10. *Essays on Org. Rem. &c.*, p. 61. 1829. *Journal Acad. Nat. Sc. Philadelphia*, vol. vi. pl. viii. f. 9, 10. pp. 123, 124, 1830. *Synopsis Org. Rem. &c.* pl. i. f. 9, 10. p. 80. 1834.)

Dr. Morton states (*Essays*, pp. 61, 62. *Synopsis*, p. 80.) that he derived his characters of the genus *Anthophyllum* from Goldfuss; and the lamelliferous portion of the coral under consideration, as represented in Dr. Morton's excellent figures, bears a strong general resemblance to some of Goldfuss's species (*Petref.* pl. xiii. f. 10, 11. pl. xxxvii. f. 15.). The fossil is probably generically identical with that represented in pl. xxxvii. f. 15. There is also a general

agreement in Dr. Morton's figure 10. (pl. i. Synopsis) with Schweigger's *Anthophyllum cyathus* (Beobachtungen, Tabular Arrangement, vi.), particularly as given in Esper (Pflanzenthier, Madrep. tab. xxiv.); but the American fossil, when preserved in its true position, clearly differs from the generic characters proposed by Schweigger, and adopted with various modifications by succeeding authors, including Goldfuss. The *Anthophyllum cyathus*, as well as the corals typical of the four other divisions of Schweigger's comprehensive genus, are lamelliferous throughout, whereas the American fossil, as beautifully shown in one of the Timber Creek specimens (*a*), consists of an upper lamelliferous portion or nucleus, and an inferior non-lamelliferous portion or hollow inverted cone.

This great peculiarity of structure apparently agrees with Lamouroux's characters of his genus *Montivaltia*: "Polypier . . . presque pyriforme, composé de deux parties distinctes, l'inférieure ridée transversalement; la supérieure presque aussi longue que l'inférieure, . . . presque plane au sommet, légèrement ombiliquée et lamelleuse" (Exposition Méthodique, p. 78.); and in his observations on the Caen specimens of *Montivaltia* he says, "elles sont géodiques" (ibid.). This peculiar structure would agree perfectly with the hollow inverted cone of the American coral, and the characters of the "partie supérieure légèrement ombiliquée et lamelleuse" accord well with the structure of the lamelliferous portion. De Blainville (Man. d'Actinologie, p. 336.) says, Lamouroux's figures are "*forte inexacte*," but there is enough of resemblance in them, particularly in figure 9. (Plate 79.) to support a generic agreement with the Timber Creek fossil, the "partie inférieure, ridée transversalement," being represented in the American specimens by the cast of the hollow cone, and the higher extension of the envelope being considered only a specific difference. Lamouroux's coral figured by Guettard (Mém. iii. p. 466. pl. 26. f. 4, 5.), but named by De Blainville *Montivaltia Guettardi* (De Bl. Man. d'Actinol. p. 336.; see also *Anthophyllum Guettardi*, p. 340.), bears even a closer resemblance to the Timber Creek specimens. Guettard graphically compares it to a "cupule de gland de chêne."

Dr. Morton, in his careful researches for analogous cretaceous fossils, refers to Faujas St. Fonds's figures of Maestricht corals, particularly to Pl. xxxviii. f. 1. 5. (Hist. Nat. de la Mont. de St. Pierre de Maestricht). Between those figures and the American coral there is a great general similarity; but a rigid comparison will show that there are important differences in the structural details, particularly in the centre of the apparently lamelliferous portion. The Maestricht fossils, or casts, are moreover wholly siliceous; and therefore, as they do not exhibit any traces of the original lamellæ, they cannot lead to the inference that the original coral consisted of two distinct structures. It is most probable that those casts represent only the terminal cup of an ordinary lamelliferous polypidom. It was the preservation of the lamellæ in the

upper part, and the total want of any trace of them in the lower, which led to the belief that the Timber Creek specimens belong to the genus *Montivaltia*.

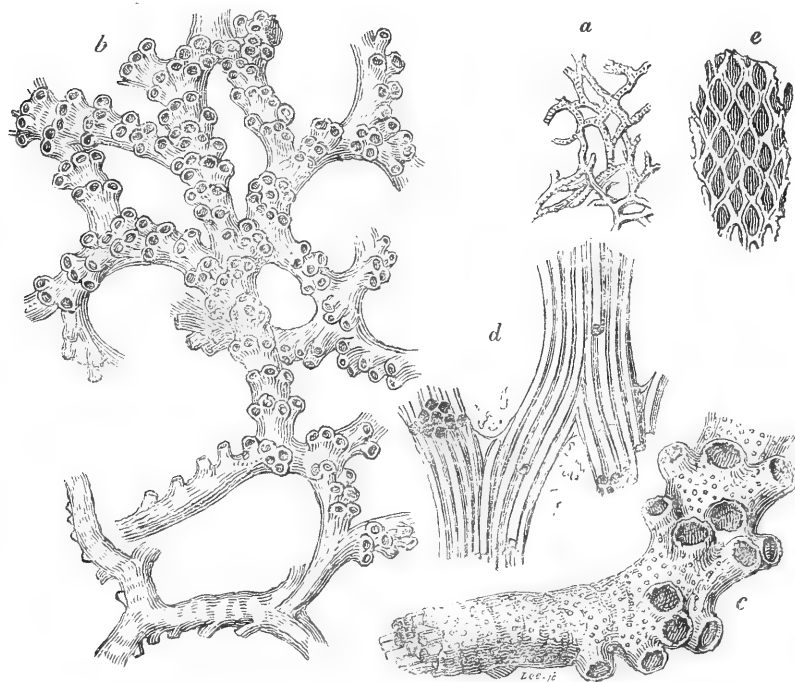
The total length of the finest specimen (*a*, see figure), is about $1\frac{1}{2}$ inches, and the greatest breadth nearly $\frac{3}{4}$ of an inch; the two portions, as before stated, are of about equal length. The whole form of the coral is an inverted cone, terminating downwards in a bent point. The lamelliferous portion is cylindrical, or slightly contracted towards the base, and there is often a tendency to bend to one side. The lamellæ are very numerous, amounting probably to eighty; and are represented in well-preserved specimens by layers of calcareous spar. They were apparently of unequal dimensions; and their lower terminations are distinctly rounded or semicircular without any signs of fracture, and, consequently, of having extended downwards into the existing hollow cone. The sides of the lamellæ were apparently hispid, rows of indentations occurring in the earthy matter, which filled the intervening spaces of the original coral. The superior terminations of the lamellæ were unequal, certain of them, probably twenty in all, protruding above the others; and these range inwards, uniting with the central contorted plates. The characters exhibited in a slightly worn-down specimen prove also that the upper termination of the coral was not cup-shaped, but flat, with possibly a slight central depression (*b*).

The centre of the lamelliferous portion consists of plates more or less horizontally contorted in the body of the cylindrical mass, and vertically at the superior and inferior terminations, forming in the latter position either a marked central rugose depression as shown in Dr. Morton's figures (*loc. cit.*), or a subordinate projecting cone (*a*).

The interspaces between the original lamellæ are occupied by earthy casts, constituting a very conspicuous portion of the coral; and from their well-defined rounded edge, as well as their decided termination downwards, they might be considered as the true lamellæ. It is clear, however, from their bearing the impression of hispid surfaces, that they are mere casts, formed while the original lamellæ existed. The material of which they consist is more or less argillaceous, and includes numerous foraminifera.

Of the nature of the portion represented by the hollow cone, no opinion can be offered. That it possessed a certain amount of solidity, and had structural details which resisted, for a time, decomposition, is evident from the earthy matter which filled the spaces between the lamellæ not having penetrated downwards into the cone, and from the marked characters of these casts. It is clear, also, from the preserved vestiges of the crust which enveloped the lamelliferous portion, as well as from the surrounding cavities mentioned by Dr. Morton, that the external wall or integument must have been thin.

Locality. Timber Creek.

2. *IDMONEA CONTORTILIS* Lonsdale. Sp. n.

- a.* Branches natural size.
b. Portion of the same magnified, and exhibiting the contorted mode of growth.
c. Part of a branch more highly magnified, to show the pores in the surface.
d. Magnified portion of the reverse side (*e.* nat. size), exhibiting the range of the tubes, exposed by fracture.

Branches compressed, bifurcated, contorted and anastomosed; tubular openings projecting, variously grouped; no marked, continuous, central line between the groups; reverse surface slightly convex, furrowed transversely, and streaked faintly by the separating walls of the tubes.

In the absence of the central line or medial ridge, and of a regular bilateral arrangement of the tubular openings, this coral differs from the generic characters of *Idmonea* as given by Lamouroux (Exp. Méthodique, p. 80.), and repeated by Milne Edwards (Ann. Sc. Nat., 2d series, vol. ix. Zool.); but it agrees in the general distribution of the openings with the latter author's enlarged figure of *Idmonea transversa* (loc. cit. Pl. ix. fig. 3.; likewise Recherches sur les Polypes; Mémoire sur les Crisies, &c.); De Blainville also, in his description of the genus, says, the openings are disposed "en demi-anneau ou en lignes brisées" (Man. d'Actinol., p. 419.). There is a slight resemblance between the Timber Creek coral and the *Cellepora echinata* of Goldfuss (Petrif. xxxvi. f. 14.), an Astrupp tertiary fossil, but which is said to be attached to a Terebratula.

The branches are slightly convex on both sides (see figures), and so greatly contorted that the reverse surface of some portions of a specimen are completely turned round. The tubular openings

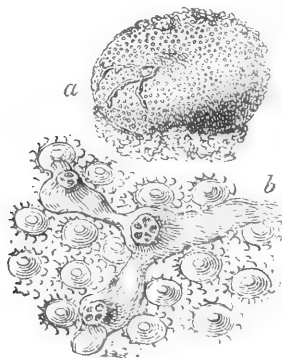
project more or less, and are variously grouped, but with a tendency to a transverse linear arrangement. The furrows between the openings are smooth, or but faintly traversed by longitudinal lines, marking the range of the tubes; they are, moreover, minutely porous (*c*). On the reverse side very small pores may also be detected, though not generally, in consequence, probably, of the thickening of the external layer by matter secreted through them. This remark applies likewise to those between the tubular openings. On the inner surface of the layer, forming the reverse side, the pores are very distinct and numerous.

The tubes are angular (*d*), and have a considerable range, bending conformably to the contortions of the branches. The substance of their walls is not often well preserved, but where it is retained microscopic foramina may be also detected.

No changes, incident upon age, have been noticed, except the probable thickening of the outer layers on both surfaces: no cases of young tubes have been observed.

Locality. Timber Creek, New Jersey.

3. TUBULIPORA MEGÆRA *Lonsdale*. Sp. n.



a. The coral of the natural size, to exhibit the general resemblance to the smaller species of *Alecto*.

b. Portion magnified, showing the characters of the attached fasciculi and the tubercular openings.

Dichotomous, fasciculi of tubes slightly conical; mouths of the tubes united in a round, slightly projecting tubercle.

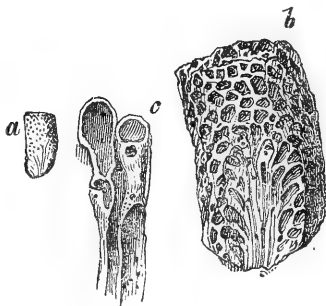
To the unassisted eye this coral presents a perfect agreement with Lamouroux's genus *Alecto*, consisting apparently of simple tubes, and not of fasciculi of 2 to 5 tubuli.

The fasciculi or branches gradually increase in breadth between the points of bifurcation, the broadest part being adjacent to the mouths. Externally they are round, but the outline of the surface is apparently modified by the papillæ of the Echinite to which they are attached. The tubuli, where they have been accidentally exposed, are arranged laterally. The tubercle, composed of the mouths, or probably the abraded base of the vertical portion of the tubuli, is reflected vertically upwards, or is inclined at a consider-

able angle: it is cylindrical, and much less in diameter than the adjacent portion of the fasciculus. The mouths themselves are not arranged in a line, or in the same manner as the tubuli, but grouped so as to occupy the least possible breadth; they are small, rounded on the exterior side, but flattened or angular at the points of contact.

Locality. Timber Creek.

4. CELLEPORA TUBULATA *Lonsdale.* Sp. n.



- a.* Portion of a branch of the natural size.
b. The same magnified, to show the elongated characters of the central cells.
c. Magnified, elongated cells from the interior of the branch, with a perfect mouth and foramen under the proximal lip. The microscopic pores in the walls of the cells are likewise given.

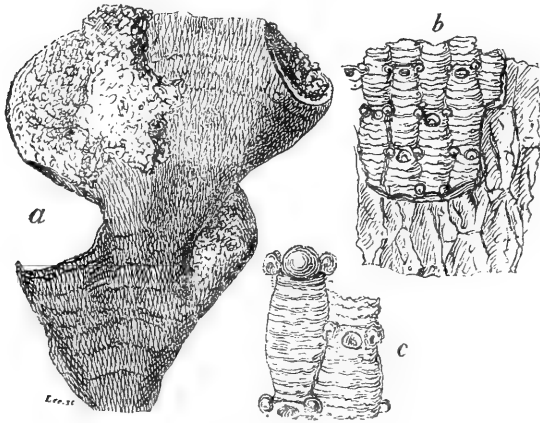
Branched; branches round, dichotomous; cells irregularly aggregated, ovoid elongated or tubular; mouth semicircular, large; proximal lip straight with a minute foramen in the centre.

The external surface of the branches rarely presents cases of perfect cells. Where they occur, they exhibit the usual ovoid form, and the mouth is well defined, being bounded completely by the distal arched covering of the cell; there is also a foramen under the proximal lip. More generally the surface presents a confused congeries of circular or angular openings, leading into ovoid cells. Internally, the branches exhibit, when fractured transversely or longitudinally, a perfectly tubular character in the cells comprising the axis of the branch (*b*), the cells being of great length and angular from lateral interference or compression; but towards the distal termination, as displayed in one instance, the ovoid form of the ordinary condition is assumed, by a swelling outwards, and the mouth is bounded by a regularly curved surface, the proximal lip being also supplied with a minute foramen (*c*). The prevailing form of the cells composing the mass of the branches is, however, ovoid, but variable in outline as well as in size and position. The cells are also much more numerous than is represented in fig. *b*.

The minute foramen on the proximal lip was probably connected with the base of the spinous process, so frequently exhibited in recent and fossil species of *Cellepora*. On the surface of the sides of the tubular cells, and also on those of the ovoid, minute connecting foramina may be detected, well defined, and occasionally bounded by an opaque, or thickened, circular line.

Localities. Lewis's Creek (South Washington, North Carolina), and Timber Creek.

5. ESCHARINA*? SAGENA.



a, General mode of growth, the exposed surface being the reverse side of a layer of cells.

b, Cells composing portion of an inner layer; also reverse side of the opposite layer.

c, Cells forming part of an outer layer; one of them with a gemmuliferous vesicle.

Foliaceous, cells in two or more opposite layers, successively encrusting, but separable; cells oblong or hexagonal, defined by a slightly depressed line, arranged in alternate rows, but not conformably in succeeding layers; outer surface of cell nearly flat, ribbed; mouth at the distal extremity, small, round; gemmuliferous vesicle large, hemispherical; accessory foraminated vesicles two, over the mouth.

In the notice of this coral (Synopsis, &c. p. 79., pl. xiii. f. 7.), Dr. Morton describes it under the name of *Flustra sagena*, but adds, "perhaps it is an *Eschara*."

This polypidom differs from described species of *Escharina* in its free, foliaceous mode of growth, in being composed of several opposite, enveloping layers, and in the facility with which the dorsal surfaces may be detached; but it has been thought advisable not to propose a new generic name for this and analogous fossil corals, the characters of *Escharinæ* being considered to be not fully ascertained. The *Cellepora nobilis* of Esper (Pflanzen-thiere, Cellep. tab. vii.) exhibits similar consecutive layers of cells, but arranged around a cylindrical nucleus and not in free plates.

The foliations are of considerable dimensions, and are variously contorted (*a*), and sometimes anastomosed. The layers are thin, but when numerous the foliations exhibit considerable thickness. Specimens presenting the opposite layers in their original position are not common, in consequence of the facility with which they separate along the medial plane. Portions only of successive layers are also to be detected, and not very frequently. The perfect outer layer was noticed in only one instance. (*c*)

* *Escharina* Milne Edwards; *Lepralia* Johnston.

Of the earliest state of the cells no positive information has been obtained* ; but it is inferred from the ribs, more or less distinctly traceable on the outer covering, that they were in the young stage entirely open, and that the outer surface was produced by a uniform development of rib-like processes from the side-walls of the cells, in the same manner as in certain species of recent *Escharina*.

In the only observed case of a perfect outer layer(c), the cells were oblong and slightly hexagonal, and separated by a faint, depressed line. The external surface was, to a small extent, convex ; and ribs, though they were not prominent, could be detected, converging from the proximal and lateral walls towards the centre ; and the medial line of junction might also be discovered. The perfect mouth, placed in the middle of the distal extremity, was small and round, and in the same plane with the outer surface, but the lips projected slightly. The hemispherical gemmuliferous vesicles were relatively large, and comparatively numerous. They were situated immediately over the mouth, and they altered the position of that orifice from a horizontal to an inclined position. The accessory foraminated vesicles were variable in outline but constant in occurrence and situation, springing from the sides of the mouth, and increasing in size as they ranged upwards and outwards. The foramen was often well defined. From the position of these vesicles, the breadth of the distal extremity was apparently much increased.

In subjacent or older layers (b) the substance of the coral was not often preserved, having been detached with the overlying series, and leaving only calcareous casts of the interior of the cells ; but where it is retained, there were no marked differences of characters, as far as observation extended, except in the absence of gemmuliferous vesicles. The mouths did not appear to have been filled up by the animal, and the foramina of the accessory vesicles were occasionally open : the depressed lines between the cells were also preserved.

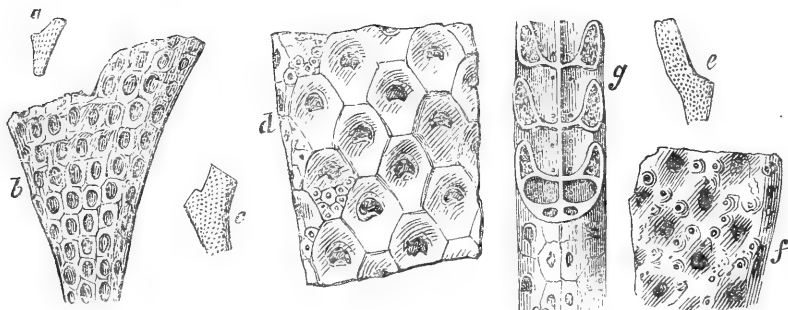
In fragments which exhibited only casts of the cells, the indications of the ribs were sometimes as strong as on the outer surface, and the form of the mouth was well shown ; but there were only very slight indications of the accessory vesicles.

Of the lateral connecting foramina nothing decided was observed in consequence of the perishable state of the layers ; but if the imperfect cells mentioned in the note* belonged to *Escharina* (?) *sagena*, the foramina were numerous.

The dorsal surface along the medial plane of separation (a) very much resembled that of *Flustra foliacea*, when artificially exposed.

Locality.—Timber Creek.

* On the surface of one specimen, some immature cells, consisting of only the dorsal and side walls, were observed, occupying the exact position of an ordinary layer of *Escharina sagena*, but there were no proofs that they belonged to that species ; and all attempts to connect their structural details with those of the coral under consideration failed.

6. *ESCHARA DIGITATA* Morton.

a. b. Bifurcated branch, natural size and magnified, consisting of immature cells with the outer surface almost wholly open, and with no indications of a distinct mouth.

c. d. Portion of a bifurcated branch, with mature cells. To the right of figure d is a cell with an uniformly depressed surface, and conjectured to have performed the office of a gemmuliferous vesicle: to the left are irregularly foraminated cells.

e. f. Portion of an aged branch, with the characters of the mature cells obliterated by external additions and the production of irregular tubercles.

g. Magnified side view of a branch, to show the position of the lateral connecting foramina within the cells; and of the small or defective cells exhibited also in the edge of figure d.

Branched, branches compressed, dichotomosed; cells hexagonally pyriform, separated by a fine lineal groove; surface sloped inwards from the periphery; mouth semicircular or semi-oval; no accessory or gemmuliferous vesicles observed; lateral connecting foramina two, terminal one.

See Dr. Morton's Synopsis Org. Rem., Cretaceous Group, United States, p. 79. pl. xiii. f. 8. 1834.

Dr. Morton states that this fossil strongly resembles *Eschara dichotoma* of Goldfuss (Petref. tab. viii. f. 15.), a Maestricht coral, and there is a perfect agreement in the mode of growth, as well as a general resemblance in the form of the cell; but a considerable difference, in structural details, is visible when the two fossils are compared. The cells in both cases are hexagonal, but the sides of those composing the Maestricht *Eschara*, as given by Goldfuss, are very nearly, if not quite equal, and they are slightly but uniformly curved; whereas, in the Timber Creek specimens, the sides are almost invariably unequal, the proximal and distal being considerably smaller than the lateral, and the curvature is variable in amount and direction, giving the cell a pyriform aspect. The relatively broad grooves between the cells in *Eschara dichotoma* are represented in the American species by a fine line: the mouth of both fossils is semi-circular, but more completely so in the Maestricht than the Timber Creek coral; in Goldfuss's species,

moreover, it is bounded, at the distal extremity, by a broad flat band which is extended around the whole periphery of the cell; while in Dr. Morton's coral the surface slopes inwards from the very edge of the cell.

These differences are not pointed out under the supposition that Dr. Morton conceived the two corals might be identical, for he was clearly aware of their distinction, but because both the Maestricht and Timber Creek deposits are members of the Cretaceous series, and the perfect agreement in generic outline with Goldfuss's figure (14 *a*), might lead a less careful observer than Dr. Morton to the inference, that the fossils are specifically the same.

The branches preserve a considerable uniformity of breadth, expanding only towards their bifurcation, and there very slightly, in consequence of the addition of one or more lateral rows. They diminish in thickness towards the edges, where they are rounded.

The cells on the opposite side of the medial line agree generally in position, and those forming the surface of the branches have a great regularity in size and relative proportions; but, at the point of bifurcation, and along the edges of the branches, small and imperfect cells may very frequently be observed, the latter exhibiting sometimes irregular pores in the external covering.

Of the earliest state of the cells no evidence was obtained; and of the condition after the formation of the side-walls only one case was noticed. It consisted (*a*, *b*) of a portion of a main branch, with part of another springing from a bifurcation. The surface of the greater number of the cells was wholly open, indicating considerable rapidity of development, or slowness in the formation of the exterior; and in only a few instances was there a commencement at the proximal extremity of the outer surface. The walls of the latest produced cells, or those at the superior extremity of the bifurcated branches, had a sharp edge without any line of separation; but in the cells of the undivided branch, and where the development of the external covering had commenced, fine grooves were perfectly visible. This great production of immature cells is analogous to many well-known recent examples.

In what was believed to be another step towards maturity, the surface of the cells was considerably developed, but the mouth was not regularly defined, the open part being large and circular. The structure of the mature cells is given in figure *d*, and in the specific characters.

The passages from maturity to what may be termed a state of decrepitude afforded some interesting structural details. In the first steps, the fine separating grooves between the cells were partially or completely obliterated, and a general thickening of the parietes was noticed; but these changes were not always most decidedly shown in the oldest cells of the branch, depending, apparently, in part upon the individual polype. In a specimen in which the above alterations were not so complete as in other cases, there appeared upon the surface of the cells several minute prominences, and one or two fractured vesicles. Some of the

intermediate stages were not noticed; but in specimens believed to be far advanced towards extreme age (*e, f*) the surface of the cells was convex, instead of being concave; all traces of lines of separation were obliterated, the mouth was irregularly shaped, sometimes with a tooth-like projection on the proximal lip, and the whole surface of the branch was beset with perforated or abraded vesicles.* No instance of a perfect filling up of the mouth, which would characterise perhaps the oldest condition of the coral, was noticed. A due preservation of the specimens, which exhibited these stages, forbade any attempt to trace a connection between the vesicles and the polype cells; but a transverse section of a mature branch exposed clearly capillary tubes, passing through the substance of the thick external covering of the cell.

The lateral and terminal foramina in the walls of the cells were well exhibited. The former, two in number (see figure *g*), were relatively large, situated near the extremities of the cell, and close to the dorsal wall. In one beautifully exposed specimen, the presumed use of these foramina in the formation of cells was instructively shown. The specimen (figure *g*) displayed the sections of a series of cells with thickened parietes, and the lateral foramina, also the rounded edge of the branch composed of a regular double row of small cells, divided longitudinally by the usual middle or dorsal layer of separation. The mouths of these cells were small and round, and might be mistaken for lateral foramina; but the boundaries of the diminutive cells, to which they were the regular openings, were clearly to be traced. The length of these imperfectly developed cells was about half that of the full-grown; and the mouths accorded in position with the situation of the lateral foramina. It is, therefore, inferred, that each minor cell was produced by means of one lateral foramen, the perfect development not having taken place, owing to the absence, in the same longitudinal row, of a full-grown anterior cell. In consequence of the quincuncial arrangement of the perfect cells, each polype had, by means of the lateral and terminal foramina, immediate connection with six other cells.

Cases of monstrosity or deviation from the normal form occur, as before mentioned, near the edges and at the bifurcation of the branches; but it is believed that some entire branches were composed of irregularly-shaped cells, and might, without care, have been assigned to a distinct species.

No traces of accessory vesicles were observed, nor any satisfactory signs of a gemmuliferous vesicle. In one case the whole surface of a cell was deeply depressed (fig. *d*), and might have formed a receptacle for the development of gemmules.

Locality. Timber Creek, New Jersey.

* These vesicles or bladders must not lead to the inference that there is any resemblance between *Eschara digitata* and the recent coral *Cellepora cervicornis*. In the former case the bladder has no regular cellular structures, while in the latter there is always a perfectly developed mouth, with accessory vesicles.

JANUARY 31. 1844.

Seymour Tremenheere, Esq., was elected a Fellow of this Society.
The following communications were read : —

1. *On the Thickness of the LOWER GREEN SAND BEDS of the SOUTH EAST COAST of the ISLE OF WIGHT.* By F. W. SIMMS, Esq., F.G.S.

THE last time the Green sand beds below the Chalk were the subject of discussion before the Society, great diversity of opinion was expressed concerning the thickness of the group of beds denominated "The Lower Green sand." To remove all doubt on this point, Dr. Fitton proposed revisiting the south-east coast of the Isle of Wight, and requested my co-operation in determining their thickness. The following vertical section of the strata, seen in the cliffs of the south-east coast of the Isle of Wight, and including the three entire groups, viz :—

1. The Upper Green Sand,
2. The Gault,
3. The Lower Green Sand,

was made in company with Dr. Fitton, Mr. Mackeson of Hythe, and the President of our Society, during a visit we made to that coast in July last

The horizontal line over which these measurements extended, that is, from Atherfield point to the Cliff on the south of St. Catherine's Down, is about three miles in length. Along nearly the whole of this line, the coast is bounded by mural cliffs, except where slips have taken place (and these are often of considerable extent), and except where "Chines" (as they are called), that is to say, deep precipitous gullies, worn by the action of brooks in the argillaceous sands, open into the sea.

Where the cliff was mural, and direct measurement was practicable, the thickness of a bed was taken by the tape or graduated rod. Where direct vertical measurement was not practicable, as, for instance, where the fall of the cliff had obscured the continuity of the beds, the spirit-level was employed, as in ordinary engineering operations. Without the aid of that instrument it would have been difficult, if not impossible, to carry on a connected series of measurement over so long a base line with any tolerable degree of accuracy. By the means employed, however, a series of vertical measures was obtained, which I consider to be a near approximation to the truth.

The apparent dip of the strata, as seen in the cliffs, and as resulting from actual measurement, near Atherfield, was to the east 2° ; but the true dip, as determined by the spirit-level at Atherfield Point, where the rocks were bare at low-water, was nearly south-east; and its amount was found to be 2° .

The junction of the Weald Clay with the Lower Green Sand is

exceedingly well defined at Atherfield Point. That of the lower green sand with the gault, though not quite so obvious as the last-mentioned junction, is yet very satisfactorily ascertained — 1st, Below the Hotel at Black-gang-Chine, where the green sand forms a line of terrace projecting beyond the gault; 2dly, On the cliff eastward and immediately above Black-gang-Chine, where gault fossils occur at the very point of junction with the lower green sand. The junction of the gault with the upper green sand is well defined on the face of the cliff south of St. Catherine's Down, east of the Sand-Rock Spring, and above the road leading from Black-gang-Chine to Ventnor. The junction of the upper green sand with the white chalk marl is very well marked, near the summit of the same cliff.

The author stated that in the section, drawn according to scale, which accompanied this notice, he had given, not only the three principal groups, but also their more remarkable and best defined subdivisions, without pretending to describe, in needless detail, all the strata of which they are composed. From the particulars which he subjoins respecting these subdivisions, the following table is extracted : —

		<i>Totals.</i>	
Chalk Marl.		<i>ft. in.</i>	<i>ft. in.</i>
Upper Green Sand.	Parallel layers of a soft rock, "hassock," which rapidly disintegrates by exposure; and of hard cherty sandstone, which, after weathering, stands out in high relief	- 37	
	Sand, with beds of stone and chert	- 67	
			104
Gault.	Light-coloured gault, becoming gradually bluer	- 43	
	Beds of decided blue colour. No fossils have been found, except in the very lowest beds	- 103	
			146
Lower Green Sand.	Lower green sand. No notice required	- 384	
	Bed containing oysters and <i>Gryphœa</i>	- 21	
	Various beds not noticed	- 269	
	A bed of argillaceous sand, containing large lenticular, concretionary masses of very hard calcareous sandstone, locally termed "the crackers." These masses, when broken, are found to contain numerous fossils	- 15	
	Blue argillaceous beds, the lowest of which approach in their character to fullers-earth. The upper of these beds contain Crustacea; the lower contain remains of Pinna. In the latter respect, these beds agree with the clay that lies beneath the sand and stone at Hythe in Kent, described in the paper read before the Society in June last. If this bed be the equivalent of the clay bed at Hythe, the crackers will represent the stone-beds at Hythe, described in the same paper. They also agree with the Hythe stone-beds, in being very nearly at the same vertical distance above the Wealden. For the purpose of comparison, the Hythe section has been drawn to the same scale as that of the Isle of Wight	- 59	
	Atherfield rock, containing many fossils	- 2 2	
	Dark greenish sandy clay, looking black when wet, containing many of the same fossils as the rocky bed	2 9	
			752 11

2. REPORT on the LOWER GREEN SAND FOSSILS in the Possession of the Geological Society. By Professor EDWARD FORBES, F.L.S.

THE collection of Lower Green Sand fossils at present in the cabinets of the Society contains 131 species of Mollusca. Of these 82 are Lamellibranchiate Bivalves, 12 Brachiopoda, 23 Gastropoda, and 14 Cephalopoda. Besides these, all well-marked species, there are a number of casts and fragments of species as yet undetermined.

Of the 131 Mollusca, 60 are additions to the list of Lower Green sand Fossils, published by Dr. Fitton in the "Geological Transactions." Of these 60 additional species, between 30 and 40 are undescribed forms. The remainder are species described in the memoirs of Leymerie, D'Orbigny, Roemer, and other continental authors, but which have been hitherto unrecorded as British, with the exception of a few included in Mr. Morris's catalogue.

All the species have been critically examined, and characters drawn up of such as are new.

The collection can by no means be regarded as complete, numerous additions, including several very beautiful species, having been very lately presented to the Society; and these there has not as yet been time to examine and place in the cabinets.

Of the lower green sand Mollusca in the collection, 35 agree with Neocomien species recorded by M. Leymerie, and about 30 with species from the Hillsthorpe and Hillsconglomerate of M. Von Roemer. Many species, which had received new names from those geologists, have proved, on examination, to be well-known British species, figured in the Mineral Conchology or elsewhere. Among these are several which are regarded on the Continent as characteristic of the so-called Neocomien beds.

Of Radiata, there are in the collection about 12 species of Polyparia and Amorphozoa, and 9 Echinodermata; of Annelida 8 or 9 species, and several Crustacea. Additions to this part of the collection are very desirable, especially better specimens of Echinodermata.

To complete the collection, fossils from the Speeton Clay, of which there are none in the Society's possession, are much wanted. The table now drawn up exhibits the species at present in the collection, and their relation to the French lower green sand fauna, and to that of Germany, as well as the British localities in which they have occurred. It appears from this table that the greater number of species are as yet only known as fossils of British strata.

[Note. It has been thought advisable to publish this report in its present form in the "Proceedings," as a record of what was done at the time. The catalogue referred to, enriched by many additions, and accompanied by figures of new species, will, it is hoped, be shortly placed in the possession of the Fellows of the Geological Society.—ED.]

3. REPORT *on the COLLECTION of FOSSILS from SOUTHERN INDIA, presented by C. J. KAYE, Esq., F.G.S., and the Rev. W. H. EGERTON, F.G.S.* By Professor EDWARD FORBES, F.L.S.

IN the descriptive catalogue accompanying this report, and referring to the remains of invertebrate animals in the valuable collection of fossils from the South of India, presented to the Society by Mr. Kaye, and increased by an extensive series of specimens collected in the same localities by Mr. Egerton, 168 species of Mollusca are enumerated, 156 of which, as far as can be ascertained, are undescribed forms. There are also a number of species of Radiata.

The results of their examination may be briefly stated as follows : —

1st. The three deposits, viz. Pondicherry, Verdachellum, and Trinconopoly, described by Mr. Kaye, are *Cretaceous*, inasmuch as there are characteristic known cretaceous fossils in the collections from all of them, whilst no fossils of any other system occur. The nearest allies of the majority of the new species are cretaceous ; and among the genera and subgenera are many which, as far as we know, are confined to or have their chief development in the Cretaceous system. The three deposits are connected with each other zoologically by the associations of certain species common to two of them, with others found in the third.

2d. Two of the three deposits, viz. Verdachellum and Trinconopoly, are of a different epoch of the Cretaceous era from the third, Pondicherry. The two former have several species in common (and those species among the most prolific in individuals), which are not found in the third. In them are found almost all the species identical with European forms. In several of the genera, of which there are many species, the forms are altogether distinct ; although, judging from the evidence afforded by mineral character and association of species, the conditions of depth and sea-bottom at the time of the deposition of the strata seem to have been the same. The difference therefore must have depended on a representation of species by species *in time* and not *in depth*.

3d. The beds, apparently contemporaneous, viz. Trinconopoly and Verdachellum, may be regarded as equivalent to the upper green sand and gault ; the European species they include being either characteristic upper green sand and gault forms, or else such as occur in those strata. The new species they contain are either closely allied to known upper green sand or gault species, or peculiar to the Indian beds.

4th. The Pondicherry deposit may be regarded as belonging to the lowest part of the Cretaceous system. In it almost all the fossils are new. Such as are analogous to known species are allied to fossils of the lower green sand of English geologists and Neocomien of the French. In the genus most developed in this deposit, viz. Ammonites, three fourths of the species be-

long to those subgenera especially characteristic of the "Lower Neocomien" of the Mediterranean basin; whilst, of the remainder, as many representatives of Oolitic fossils occur as of upper green sand. The resemblance between the Ammonites of this part of the collection and those of Castellane, in the south of France, is very remarkable, though the specific identity of any of them is doubtful. Having seen no account of the Conchifera of the Castellane beds, I cannot say how far the analogy is borne out among the bivalve Mollusca among the Indian species, of which there are many very peculiar forms.

5th. Considered in regard to the distribution of animal life during the Cretaceous era, this collection is of the highest interest. It shows, that during two successive stages of that era the climatal influence, as affecting marine animals, did not vary in intensity in the Indian, European, and American regions, whilst the later of the two had specific relations with the seas of Europe, which are absent from the earlier. The cause of this remarkable fact is not to be sought for in a more general distribution of animal life at one time than at another, but rather in some great change in the distribution of land and sea, and in a greater connection of the Indian and European seas during the epoch of the deposition of the upper greensand, than during that of the lower. To this cause must also be attributed the peculiar tertiary aspect of the Indian collections, depending on the presence of a number of forms usually regarded as characteristic of tertiary formations, such as *Cypræa*, *Oliva*, *Triton*, *Pyrula*, *Nerita*, and numerous species of *Voluta*, the inference from which, since not one of the species is identical with any known tertiary form, should not be that the deposits containing them are either tertiary or necessarily connected with tertiary, but that the genera in question commenced their appearance *earliest* in the Eastern seas, which, when we recollect that in those very seas at the present day, are found the great specific assemblages or capitals of those genera, whilst they have either disappeared or have few representatives in the seas of other geographical regions, is exactly what we should expect, *à priori*, to find. This fact would go far to support the theory, that genera, like species, have geographical birth-places as well as geographical capitals.

The fact, that of the few species found in the Indian cretaceous beds which are common to the same beds in distant regions, the majority are such as range through several deposits of different ages, supports the probability of a law which I have elsewhere indicated, viz. that *the range of the geographical distribution of species is usually correspondent to the range of their distribution in time.*

The probability of the proposed law, that the *marine faunas of distant localities, under similar conditions of climate, depth, and sea-bottom, maintain their relations rather by the representation of forms by similar forms, than by identity of species, is also borne out by the examination of these collections.*

These inferences can be only put forth as provisional, until a thorough examination of the deposits described by Mr. Kaye in their stratigraphical relations be made, and the fossils of those localities which he did not visit have been still further examined on the spot. To the palæontologist his collections are invaluable, as the specimens are in so fine a state of preservation, as to permit of an examination of their minute structure.

The descriptions of fifteen of the Trinconopoly species in the catalogues were furnished to Mr. Kaye by Mr. George Sowerby.

[*Note.* With regard to this report, it was also intended that it should have been accompanied by a descriptive catalogue of the fossils, and by figures of new species, and it is in so far, therefore, incomplete. It is published in this place as an indication of the important results actually arrived at by the study of these interesting fossils.—*Ed.*]

4. *On the PERMIAN SYSTEM as developed in Russia and other Parts of Europe.* By RODERICK IMPEY MURCHISON, Esq., F.G.S., V.P.R.S., and M. E. DE VERNEUIL, Hon. Mem. Geo. Soc. of London.

ON the part of his associates, M. de Verneuil and Count Keyserling, and himself, Mr. Murchison has previously explained in the Proceedings of the Geol. Soc. the nature of the various deposits which constitute the subsoil of European Russia. As in all other parts of the world which have been adequately examined, the Silurian rocks are those which contain the earliest forms of animal life, and in Russia they are overlaid by Devonian and carboniferous deposits, each of which is there singularly well defined by its organic remains and regular superposition.

In common with many other geologists, Mr. Murchison was formerly of opinion* that the above-mentioned three systems constituted the whole Palæozoic series, but the examination of Russia and Germany has led him to include also therein the next group in ascending order, or that to which he had assigned† the name of Permian.

When two or more conterminous formations are shown to have a community of fossils, it has recently been deemed essential to group them under one name; and following the practice of assigning to any such newly classed group a geographical name

* See "Silurian System," p. 46. *et seq.* In England Professor Phillips has, however, some time maintained that the fossils of the magnesian limestone ought to be grouped with the inferior strata.

† See "Letter to M. Fischer Von Waldheim, Sept. 1841"; Leonhard's "Jahr Buch," part i. p. 91 1842; "Phil. Magazine," vol. xix. p. 418.

derived from the region where the strata are best developed, the term "Permian" was employed. This system was first proposed to embrace the deposits known in Germany as the Rothe-todte-liegende, Zechstein, Kupferschiefer, &c., and in England as Lower New Red Sandstone, Magnesian limestone, &c.

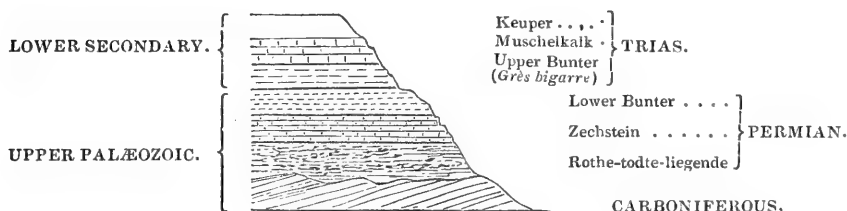
In communicating some of the results of a journey in Poland and Germany during last summer, Mr. Murchison, one of the authors of the present memoir, states that his object is to show that his first view concerning the inferior limit of this system is correct—to extend its upper limits, and from the distribution and character of its organic remains to demonstrate that it is of palæozoic age.

Near Zwickau in Saxony, and Waldenburg in Upper Silesia, productive coal-fields (in the latter country recumbent on carboniferous limestone) are unconformably surmounted by red conglomerate, sandstone and shale (the rothe-todte-liegende), which in those countries, as in Thuringia and Hesse Cassel, pass conformably upwards into the Zechstein or its equivalents. The same relations of a lower sandstone to the Magnesian limestone are, indeed, well known in England, and have been pointed out in detail by Professor Sedgwick. Seeing that these two deposits are so intimately associated, few, if any, geologists would wish to disunite them; but the question arises, what is the uppermost limit of this group. In Russia, beds of limestone identified with the Zechstein and Magnesian limestone by their organic remains are overlaid by a great thickness of marls, sands, and conglomerates, containing some of the same types of life as the lower members, particularly the plants which are very closely allied to and are in some instances identical with the vegetables of the carboniferous era. It became therefore desirable to ascertain whether similar palæozoic features were to be found in other parts of Europe. Now in Thuringia and Hesse Cassel, the Zechstein is, in numerous localities, conformably surmounted by red and spotted sandstones, in which no traces of fossils distinct from those of the Permian era are observable, the only land plant found in them (the *Calamites arenarius*) being inseparable from well-known carboniferous forms. This overlying sandstone being perfectly conformable to the Zechstein, may, it is conceived (like the overlying sandstones of Russia), be classed with that rock. In making this suggestion, the authors disavow the intention of derogating in any respect from the Trias of German geologists, also a tripartite system, and of which the muschelkalk is the centre, with certain red and mottled marls and sands beneath, and the keuper sandstone above. The Triassic system does not contain a single Palæozoic form, whether animal or vegetable, whilst the fauna and flora of the Permian are both so connected with the carboniferous and inferior systems, that they evidently constitute the last remnant of the same era. In the whole geological series, therefore, no two systems are more completely separated than the Permian and the

Trias, the one forming the uppermost Palæozoic stage, the other the base of the secondary deposits.

After showing that the “Grès de Vosges,” as described by M. Elie de Beaumont, is one of the arenaceous equivalents of the Permian system, and after alluding to its development in the neighbourhood of Strasburg and in other parts of Europe, where it is well separated from the Trias, attention is directed to the fact, that as far as researches had yet gone, the Trias is always conformable to the Permian, whilst the “*rothe-todte-liegende*,” or base of the latter, is frequently unconformable to the carboniferous rocks, on which it rests, and out of whose detritus it has often been formed. These phenomena, say the authors, prove that the most marked distinctions between the fossils of succeeding formations cannot be referred to physical revolutions of the surface; for in the examples cited there is a sequence of congeneric remains, where the succession of the strata has been powerfully interrupted (Carboniferous to Permian), and a total change of fossils where the contiguous formations are conformable (Permian to Trias).

These relations are expressed in this diagram :—



The Permian fauna is then considered, and is said to exhibit the last of the successive alterations which the Palæozoic animals underwent before their final disappearance. The total number of Permian species known to the authors in different parts of Europe (without reckoning certain ichthyolites not yet named, and a few doubtful forms of shells) is 166, of which 148 are characteristic of the system, 18 only being found in the subjacent Palæozoic rocks. The Brachiopods being viewed as the shells of most value in determining the durations of the ancient rocks, it is stated, that 10 out of the 30 Permian species are common to this system and the carboniferous. After some observations on the species of *Productus*, *Spirifer*, *Orthis*, *Terebratula*, *Leptæna* (*Chonetes*), which have lived on from earlier periods, it is remarked that no form of the *Pentamerus*, a genus peculiarly characteristic of the Silurian strata, has yet been found in the Permian strata, whilst the Brachiopod most frequent in the latter is the *Productus*, a genus very abundant in the carboniferous or conterminous deposits, but unknown in the Silurian. Among the Conchifers

(26 in number) the *Modiola* is very characteristic of the Permian system, both in Russia and England; and though the large species of *Axinus* so well known in England has not yet been found in Russia, its place is there taken by two other species of the same genus. The *Avicula* is also a good Permian shell, the *A. Kazanensis* being the best type in Russia, whilst the *A. antiqua* is there common to this deposit and the carboniferous.

The Gasteropods, so abundant in the carboniferous era, have undergone great diminution before the formation of the Permian strata, and have had great difficulty in accommodating themselves to new conditions; still more so the Cephalopods, for the forms of *Goniatites*, *Nautili*, and *Orthoceratites*, so very common in the preceding epoch, are almost unknown in this system, a fragment or two of one genus (*Nautilus*?) alone having been found in all parts of Europe. This scarcity of Cephalopods at the close of the Palæozoic series has a remarkable parallel in a subsequent geological period; for as these animals were reproduced in vast abundance and under many new forms in the Triassic, Jurassic, and Cretaceous systems, so towards the termination of the last of these we perceive a second and similar disappearance of the greater number of the shelly Cephalopods. The extreme reduction of the Gasteropods at the close of the cretaceous period, as indicated by M. Alcide D'Orbigny, is also pointed out as an additional feature of analogy to the Permian changes. Trilobites, so eminently characteristic of the Silurian system, and which dwindle away to a few small species in the carboniferous system, are unknown in the Permian of Western Europe and in Russia, and are only represented by a species of *Limulus*. Fishes, on the other hand, are numerous in proportion to the other Permian classes, 43 or 44 species being named, and several from Russia being yet undescribed; these are all, with one exception, absolutely peculiar to the stratum in which they occur, thus confirming the truth of the generalisation of Agassiz, that these vertebrata mark with great precision the age of the stratum in which they are found. Lastly, the Permian beds of Russia, like the Dolomitic conglomerate of England and the Kupferschiefer of Germany, contain bones of thecodont Saurians, indicating the earliest appearance of animals of that high organisation, and their direct association with Palæozoic shells and plants, some of which are undistinguishable from true carboniferous species.

After thus following it back *in time*, the Permian fauna is next considered in horizontal extension or *distance*, the fossils of Russia being compared with those of similar age in western Europe. The number of species collected by the authors in Russia is 53 or about one third of the total number of the whole European fauna of the period, and of these 32 are peculiar to Russia, a large number when the recency and rapidity of the survey of the authors is adverted to; and when it is considered that 33 species only were found by Professor Sedgwick in deposits of this age in England, and 41

according to the recent tabular view of Geinitz is the total number known in Saxony where the Zechstein is very fully elaborated. Like other formations of synchronous age when at great distances from each other, the Russian succession of Permian strata cannot be brought into a detailed analogy with that of western Europe. Instead of occupying a fixed place like the calcareous beds which represent the Zechstein, they inosculate with great thicknesses of fossiliferous grit, whilst Saurians and fishes with certain *Producti* and *Modiola*, as well as most of the plants, unquestionably occur in conglomerates, tufaceous limestones, and marls, which overlie the beds which contain Zechstein or Magnesian limestone fossils. In Germany, the Protosaurus belongs to the Kupfer-schiefer which is below the Zechstein, whereas in Russia all the cupriferous and sauroid beds are above that rock.

In analysing the species common to the Permian system of Russia and the rest of Europe (by stating the number which have lived on from the carboniferous to the Permian, and the diminished proportion of the latter), Russia alone is appealed to, and three only of the Permian *species* of that country are found to descend into the Palæozoic rocks. The authors, therefore, infer that these results necessarily prove the existence of a relation between the greater or less duration of species and their propagation or extension to distant parts, thus confirming a law previously announced by one of them.

Some detailed observations then follow on the species in each class found in Russia, and Mr. Lonsdale is cited as having assured them that although the Permian corals are evidently Palæozoic in their generic characters, there is not a single species which is identical with a carboniferous form; and it is also remarked that of 20 species of Brachiopods found in Russia 8 are peculiar to that country.

Lastly, deriving their knowledge of the specific character of the plants from the examination of M. Adolphe Brongniart, aided by Mr. Morris, who had previously examined them, it appears certain, that whilst all the forms indicate a continuation of vegetable life of the same nature as that which prevailed during the carboniferous era, there are a few species (*Neuropteris tenuifolia*, *Lepidodendron elongatum*, and *Calamites Suckovii*) which are identical with carboniferous plants, and not one which can be compared with a triassic plant.*

The results of the inquiries of the botanist, the authors conclude by remarking, are therefore completely in accordance with those

* The species of plants, ten or twelve in number, which have been found in the Kupfer-schiefer or the sandy beds associated with the Zechstein in Germany, are chiefly marine fucoids, and have been termed *Caulerpites*. According to M. Adolphe Brongniart, the only terrestrial plants of these German strata are the *Teniopteris Echardi* (Germar), and a *Neuropteris* mentioned by Naumann, which not being determined must be considered doubtful.

of the palæontologist. They clearly prove that the Permian system is the uppermost stage of that long Palæozoic series, which, commencing with the lowest Silurian rocks, presents a connected succession of animal and vegetable life, the last traces of which passed away with the termination of the strata under review. Until Russia was explored, the upper member of these ancient rocks had scarcely afforded a trace of terrestrial plants. Neither in the British Isles nor in Germany had there been found more than one or two species of land plants in deposits of this age, not one of which has yet been fully identified or described. Now in reference to the Russian species, such of them as had been previously alluded to by other writers were placed by some in the carboniferous rocks, by others in the New Red Sandstone.* Our sections, however, have shown that neither of these views is correct; and as the Russian plants to which we have called attention, occur for the most part in strata distinctly *overlying* beds containing the fossils of the Zechstein, it is clear that certain red sandstones, marls and conglomerates, above that rock, belong to our Permian group, are wholly distinct from the Trias, and are truly Palæozoic.

We repeat, therefore, that we have now adduced ample botanical as well as zoological and stratigraphical evidence to vindicate the application of the collective word *Permian* to a succession of strata which had not been previously united through their geological relations and organic contents.

These proofs will, we trust, be considered as still more strongly borne out by the grandeur of the phenomena to which we have appealed; for the Permian deposits of Russia repose upon carboniferous strata throughout more than two thirds of a basin which has a circumference of not less than 4000 English miles.

A detailed tabular list of the animal remains of the Permian system in Europe was also given, mentioning the names of the authors who have described each species, the localities at which it has been found, and its vertical range in the Palæozoic series. This table will appear "in extenso" in the forthcoming work upon Russia, and in the meantime the following recapitulation is subjoined; but the authors express their regret that their table was drawn up without the benefit of the long-promised assistance of Professor Agassiz. His observations on a few of the Permian ichthyolites which were submitted to him will increase the number of that class of fossils.

* See a very recent memoir by M. Yasikoff, "Bull. de Moskou," 1843, part ii. p. 237., in which he refers an interesting portion of the Permian rocks described by us upon the Kama, and between that river and the Sok, either to the *New Red Sandstone* or the *Carboniferous Limestone*.

Recapitulation of the Fauna of the Permian System in Europe.

Classes.	Genera.	Total Number of Species in Europe.	Species exclusively peculiar to the Permian system in Europe.	Species found in older formations.	Species found in Russia.			
					a. Peculiar to that country.	b. Previously found elsewhere.		
						In the Permian and older formations.	In the Permian beds exclusively.	In older formations exclusively.
Polyparia - - - -	7	15	13	2	3	1?	2	
Echinodermata - - - -	2	2	1	1				
Conchifera, Ord. Brachiopoda	7	30	20	10	8	3	4	5
Ord. Dimyaria -	10	26	26		8		3	
Ord. Monomyaria	5	16	15	1	4		3	
Mollusca, Ord. Gasteropoda	11	22	19	3	3			
Ord. Cephalopoda	1	3	3		1			
Annelida - - - -	1	2	2					
Crustacea - - - -	2	2	2		2			
Pisces - - - -	16	43	42	1	2			
Reptilia - - - -	4	5	5		1			
Total - -	66	166	148	18	32	3 or 4	12	5

FEBRUARY 21. 1844.

The following communications were read:—

1. *Some Remarks on the WHITE LIMESTONE of CORFU and VIDO.*
By Captain PORTLOCK, R.E., F.G.S.

As I have reason to expect that I shall hereafter be able to prepare a detailed account of the Geology of the Ionian Islands, and have at present but few data for a description of even the limited portion of the country as yet examined, I now only offer a few remarks on that portion of the white limestone which is adjacent to the city of Corfu, and occupies the whole of the Island of Vido, and on the more recent strata connected with it.

On approaching Corfu the physical aspect of the country is very striking. Monte Decca on the south, and San Salvador on the north, the former with its sharp, broken, rugged outline, the latter with its conical peak rising from a long ridge, and both exhibiting steep faces marked by numerous deep furrows, by no means recal the ordinary forms of limestones in our more northern countries;

but the type they present will, I think, be found to have a considerable geological range.

In the Venetian harbour of Govino a singular variety of this limestone may be seen, and is thence traceable in rough knolls running in a westerly direction to the north of the village of Potamo. Its dark, rugged and often ochreous aspect, its sonorous fracture, and its impurities, are strong features of distinction between it and the ordinary white limestone. It is traversed by numerous crystalline veins of a yellow saccharoid carbonate of lime which I have little doubt is highly dolomitic; and it is full internally of small bubble-shaped cavities, some of which are empty, and others contain a fine powder, the nature of which I have not yet determined. I believe this limestone to be of volcanic origin, or at least much changed, although no ordinary volcanic or other igneous rocks have as yet been discovered in the island.

Returning now to the white limestone of Vido and the vicinity of Corfu, it will be necessary first to consider whether the geological age of any part of it can be determined, and this is important since, according to Dr. Davy, it belongs to the carboniferous limestone and a conglomerate associated with it represents the Old red sandstone, while, according to other accounts, the white limestone is oolitic, and the conglomerate tertiary.

The adjacent mainland with which these Corfu and Vido beds must be associated contains secondary strata, considered to be oolitic, and much resembling in mineral character the hardened chalk of England and Ireland; and Mr. Strickland, in describing the Geology of Smyrna, mentions that the more compact beds of yellowish limestone of that neighbourhood resemble the secondary limestones of the Ionian Islands. The former, however, are known by their fossils to be of lacustrine and tertiary origin. Mr. Strickland also, in alluding to the Geology of Zante, considers the lower beds as Apennine limestone, and the upper ones as tertiary; and the presence of Hippurites renders it probable that the former at least is of the Cretaceous period.

Restricting myself to the description of the limestone of Vido and the opposite shore of Corfu, I may first observe that the greater portion, such as for example that of the citadel rock, the height of Fort Neuf and of Fort Abraham, is very indistinctly bedded, and vertical cleavage is visible on a large scale, more particularly at the citadel. I have as yet in vain sought for fossils at either of these localities, though the rock of Fort Abraham strongly resembles that of Vido, which contains a considerable quantity of them. Immediately below the citadel rock, forming its base, and dipping under it, is the limestone of Cape Sidero which is composed of numerous and often minutely laminated beds, from half an inch to several inches in thickness. These beds are associated with layers and nodules of flint, and very often present a highly curious and interesting character, being made up of angular fragments of the limestone, with occasional flints slightly displaced and re-cemented together: and this brecciated structure is sometimes so

minute that it can only be detected by a lens, whilst in other cases it is coarser, and then readily disintegrates. At Cape Sidero the surface of the brecciated beds appears to me to have suffered erosion prior to the deposition of the other rock, portions of which are found in hollows on its surface. The same brecciated beds are seen more to the south, and may therefore underlie the massive beds of Monte Decca, just as they here do those of Cape Sidero. Similar alternating and highly laminated beds of white limestone and flints occur at the base of Fort Neuf, and again in Vido, at the base of the Tower Hill. Up to this geological point, I have as yet found no fossils, but in the massive limestone of Vido the case is different, and having fortunately noticed a fragment on the face of one of our quarries, I directed the attention of the workmen to the fact, and they were not long in discovering more. As the surface of Vido is only gently undulated, and there is no marked section, I have not yet been quite able to satisfy myself whether this limestone should, like that of the Corfu citadel, be considered to lie above the laminated beds, or below them. If the latter, the case is rendered easier. This limestone, like that of Fort Abraham, is full of fissures which are often filled up with ochreous matter, and even in the finer fissures traces may be noticed of oxide of iron.

The fossils are very locally distributed: at the first fossil locality *Terebratulæ* only were discovered; but at another, not many hundred yards from it, *Ammonites* are in abundance: these latter are, however, always in such a condition, from the splintery character of the bed containing them, that specific identification is almost impossible, although I am inclined to think that they belong to Von Buch's division, *Planulati*, and therefore may be oolitic. Portions also of *Univalves* occur. Returning to the *Terebratulæ*, some of the first specimens resembled those of the chalk; but more perfect specimens presented the character of one of Von Buch's divisions, *Acutæ*, which as yet appears to go no further upwards than the oolites.

From a careful comparison of these fossils with the species most nearly allied, (*T. pala* and a species from the lower oolites of Dundry), I am induced to believe that the species which I obtained is new, and I propose to name it provisionally *T. Seatoniana*, in honour of the present Lord High Commissioner, who has expressed himself anxious to promote a geological survey of the islands. I think also the character of the species affords strong ground for believing that the strata here belong to rocks as low in the series as the oolites.

With respect to the tertiary strata, I can at present only state that in Corfu I believe that we have all the varieties (including the gypsum), mentioned by Mr. Strickland as occurring at Zante; and I consider there is little doubt that the range of strata extends from the newer Pliocene to Miocene, if not Eocene. In an extensive excavation in the citadel, a yellow indurated calcareous sand was cut into, and a beautiful, though small section exposed; dark laminated clays were interstratified with the sand, and associated with

them was a seam of lignite (5 inches thick), which along the line of the excavation (450 feet in extent) exhibited numerous small faults at which the clay was always curiously contorted. Under the seam of coal was a more indurated portion of the calcareous sand, approaching to the character of hardened marl, and in this numerous examples of a Univalve were found, strongly resembling a *Buccinum* from Touraine.

2. *Account of the STRATA observed in the Excavation of the BLETCHINGLEY TUNNEL.* By FREDERICK WALTER SIMMS, F.G.S. M. Ins. C.E.

A FEW months ago I had the pleasure of presenting to the Geological Society some fossils collected by me in the course of the construction of the Bletchingley Tunnel, upon the line of the South Eastern Railway. These fossils consisted of bones of the *Iguanodon*, *Lepidotus Mantelli*, and five specimens of the plant *Clathraria Lyellii*. I now request the Society's acceptance of a fine specimen of the *Lepidotus Mantelli*, which was found in the excavation about two hundred yards from the western extremity of the tunnel.

The range of hills formed by the escarpment of the lower green sand extends between Red Hill and Tilburstow Hill, and its direction is nearly from west to east. Between Bletchingley and Tilburstow Hill, this range sends off a spur in a southerly direction. It was through this spur, in a line nearly parallel to the sand range, and about a mile to the south of it, that the railway tunnel, and the excavation at each end, were carried. The spur, in the line of the cuttings, consisted chiefly of Weald clay.

It was proved by the railway cuttings that this spur formed part of an anticlinal axis, which, as far as I can judge, extends across the Weald from the chalk of the North Downs in Surrey, between Merstham and Godstone, to the chalk of the South Downs in Sussex, near Ditchling. The surface waters that fall on the western side of this axis form feeders to the rivers Mole and Adur; those that fall on the eastern side feed the sources of the Medway and the Ouse.

In the excavation, at the east end of the tunnel, the beds were parallel to each other, and also to the surface of the ground, rising westward at an angle of about two degrees. The only organic remains, worthy of note, found in this part of the work, were a number of vertebræ of the *Iguanodon*, which I presented to the Museum of the College of Surgeons. Many remains had been thrown away, although I had given orders to the contrary.

As the work advanced towards the anticlinal axis, the strata showed symptoms of considerable disturbance, having numerous faults and displacements which occasioned much trouble and difficulty in the construction of the tunnel. On the west of the axis, near the level of the roof of the tunnel, a detached mass of sand-rock, about fifty feet in length, lay across our path. From this a

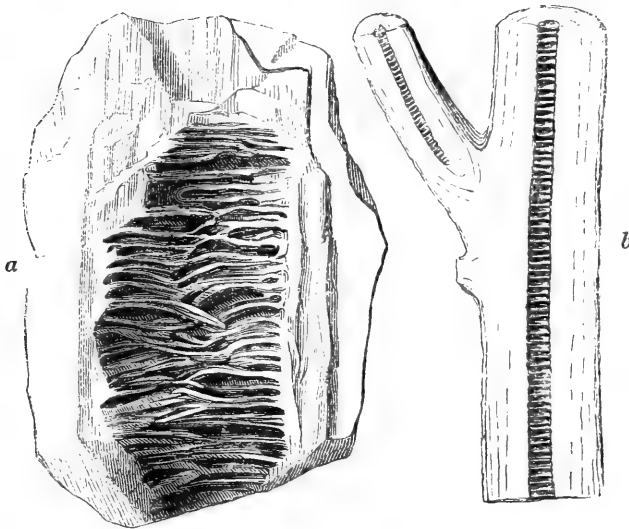
great body of water was discharged into the workings. The rock disappeared abruptly. The chief fossil remains which were found in the course of the tunnel works, were those before named, which are now in the possession of the Society.

The excavation at the western end of the tunnel, from whence the specimen of *Lepidotus Mantelli* was obtained, was full of faults and displacements, the strata dipping in various directions from W. by N. to E., and at almost every angle from 5° to 60° . This state of things caused much trouble on the south side of the excavation, by the continual slipping in of the earth; but on the north side no slip took place, and the slope stands apparently well. At the western end of the excavation, the ordinary dip was about 13° N.

In this cutting there were beds of sandstone, bearing a very strong ripple mark; these beds partook of the general disturbance.

The well-known displacement of the beds of the lower green sand, exposed on the road-side near the top of Tilburstow Hill, is about one mile and a quarter north-east of the excavation I have been describing.

3. *Remarks upon STERNBERGIÆ.* By JOHN S. DAWES, Esq., F.G.S.



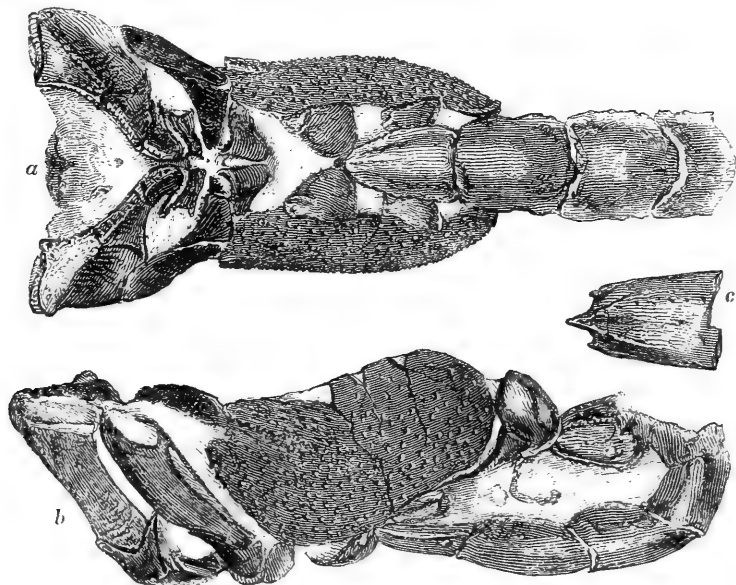
a. Fragment of *Sternbergia*, showing the internal central structure apparently lamellar.

b. Portion of the branch of a walnut tree, showing somewhat similar structure.

In the autumn of 1838 certain specimens of vegetable remains were discovered in the coal grit at Oldbury, near Birmingham, which appeared to show, very distinctly, the internal structure of those remarkable fossils, the *Sternbergiæ*. The circumstance was

considered, at the time, completely to corroborate the opinion that they were distinct plants, but having recently examined these specimens with more attention, and having had an opportunity to compare them with others, since discovered, I am enabled, I believe, to point out that these curious columnar forms are merely casts of the medullary cavities of stems or branches of trees, similar to that at Darlaston, lately described; for, upon one of the fossils alluded to, the interior of which is composed of a series of horizontal plates, we find that a part of the woody tissue of the tree is still attached to the column, and another specimen which shows, upon its exterior, traces of the characteristic rings, exhibits also a considerable portion of adhering wood. But more direct evidence is afforded by a branch, now converted into ironstone (see fig. *a*), down the centre of which a distinct arrangement of similar plates may be observed, occasionally anastomosing or rather merging one into the other, exactly as the external forms of *Sternbergia* would lead us to expect; and a smaller specimen from another district (North Staffordshire) appears still more clearly to show this connection. I may also mention that the pith of recent wood (*Juglandaceæ*), on losing its moisture, has occasionally been found to separate, after a manner somewhat similar (*b*). It is rare, however, that specimens in the fossil state, retaining this structure, have been met with, the plates having only been preserved when mineral matter has atomically replaced the cellular tissue, the plants having previously been in a dry or partially decayed state. In general, the material has filtered into and filled up the interstices, producing the usual cross-barred or ringed appearance of these fossils. Sometimes, cylindrical casts may be found which are marked externally by sharp, longitudinal, irregular striæ, representing probably a portion of the medullary sheath. The whole of the cellular tissue, in such cases, has previously been carried away; but a fine tree at Darlaston has afforded proof that under peculiar circumstances the mineralizing process may commence soon after the fall of the plant. Thus, in all probability, the central column of that specimen will retain the cellular structure. In conclusion, I may allude to the isolated and peculiar fragmentary state in which these cylindrical bodies occur. We find no attached branches, no roots, no leaves or leaf-scars; indeed, there is a total want of every part of a vegetable, by which these fossils might be identified as distinct plants: for the carbonaceous covering, now and then met with, and supposed to have been the bark, being sometimes very irregular is most likely accidental, or in some cases may arise from portions of attached wood having become converted into coal. Should the discovery of further specimens more completely prove these views respecting *Sternbergia* to be correct, we may perceive from their occurrence in, I believe, all our coal fields, how frequently a small cylindrical column alone remains when every other vestige of the magnificent plant from which it originated has been lost.

4. On the *THALASSINA EMERII*, a fossil Crustacean, forwarded by Mr. W. S. MACLEAY, from New Holland. By T. BELL, F.R.S., Professor of Zoology in King's College, London.



Thalassina Emerii Bell.

- a. View of the under side, showing the tail turned over upon the belly.
 b. Side view.
 c. End view, showing the rostrum only.

THIS fossil, forwarded from Mr. Macleay and brought by Lieutenant Emery from Australia, belongs to the typical genus of a very remarkable family of decapod Crustacea, the *Thalassinidae* (*Thalassinien*s of Milne Edwards), as Mr. W. S. Macleay has surmised. Of the genus in question, *Thalassina*, but a single recent species is known, and little has been ascertained respecting its habits. There is, however, reason to believe, that in this respect it agrees with the species most nearly allied to it in structure, several of which being found on our own coasts have afforded opportunities for more accurate observation. These, as far as their habits have hitherto been traced, are all of them burrowers, making their way to a considerable depth in the sand at various distances from the shore. The species of the genus *Gebia*, which is very nearly allied to the present, are all to be obtained by digging in the mud or sand at low tide; and the *Gebia stellata*, as stated by Dr. Leach, form subterranean, horizontal, and winding passages, "often of a hundred feet or more in length." The same habit is also known to belong to *Callinassa*, another nearly allied genus.*

* The structure of these animals is adapted only for this mode of life, and is exhibited typically in the present genus. The narrow semicylindrical abdomen,

The recent species of the genus to which the fossil belongs, *Thalassina scorpioides*, is stated by Leach*, Desmarest†, and others, to be a native of the Indian seas. Milne Edwards on the other hand gives the coast of Chili as its habitat. It is not impossible that it may have been found in both these localities; a specimen which I have in my possession was said to have been brought from India, but of this I have no positive evidence.

The fossil, which I propose to designate, after its discoverer, *Thalassina Emerii*, consists of the sides of the carapace, in tolerable preservation, the dorsal portion being quite lost; the first four joints of the first and second pairs of legs are tolerably perfect; of the third and fourth pairs the basal joints alone remain, and the fifth pair is lost. The whole of the abdomen, with the exception of the third segment, is very perfect; it is abruptly bent forward upon itself, the terminal joint resting beneath the thorax, between the third and fourth pairs of legs (*fig. a*). The rostrum also is very perfect, broken off from the carapace, and lying vertically between the anterior legs (*fig. c*). It is prolonged into a grooved triangular tooth, and there is a small prominent tubercle on each side, at a short distance from it. The raised lines, circumscribing the rostral tooth, are continued backwards to some distance, as is also its deep median groove. A second raised line is continued backwards from the small denticle, or tubercle, on each side.

The similarity between this species, as far as the state of the fossil will allow of the comparison, and the recent one, is so great, that there is some difficulty in fixing upon valid distinguishing characters. It differs, however, in the proportion of the epimeral or lateral portions of the abdominal segments, which are somewhat less developed in the fossil than in the recent species, and in the form of its terminal segment, or middle lobe of the tail, the length of which is to its breadth in the fossil as 8 to 6, and in the recent species as 11 to 6. The sides of the carapace are, in the former, somewhat more uniformly covered with minute raised points, which, in both species, render the surface distinctly scabrous.

This specimen derives additional interest from its being the only fossil crustacea which has yet been found in New Holland.

the attenuated lateral lobes of the tail, and the filiform appendages of all the abdominal segments, evidently unfit them for swimming; whilst their fossorial habits are amply provided for by the strength and flatness of the two anterior pairs of thoracic limbs, which are admirably adapted for excavating the sand or hardened mud in which they reside.

* Zool. Miscell. iii. Mal. Brit.

† Consid. Gener. Crust. Dict. des Sc. Nat.

III. TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

- I. *Remarks on the MOLLUSCOUS ANIMALS OF SOUTH ITALY, in reference to the Geographical Extension of the Mollusca, and to the Mollusca of the Tertiary Period.* By Dr. A. PHILIPPI.

[From the *Archiv für Naturgeschichte*, vol. x.]

DURING my last two years' residence in Naples and Sicily, in the years 1838 and 1839, I have had an opportunity greatly to extend my earlier researches on the mollusca of Sicily, and the fossils of that tribe of animals whose remains are there so exceedingly abundant. Amongst other things, I have been enabled to bring within the sphere of my observation the group of tertiary fossils of South Calabria, which district I have traversed in several directions, from Cape delle Armi to the ancient Crotona, and have now published a second volume of my "*Enumeratio Molluscorum Siciliae*," in which I enumerate 814 species of living mollusca, and 589 fossil; whilst in the first only 540 living, and 367 fossil species appear; so that the additional volume contains 274 living and 222 fossil species, which are wanting in the first. In this new work 258 species are figured in 16 plates. Among the 274 newly described species, there are, however, about 95 which I have not myself seen, or of which I have some doubt whether they really are indigenous in South Italy; and many of these may require to be struck out of the list, especially several of the numerous *Helices*, described as Sicilian by Messrs. Aradas, Calcara, Testa, and other naturalists. Since, however, the descriptions of these new species are often unsatisfactory, I have avoided offering an opinion concerning them, and have contented myself with giving an account of them in the words of the author. Owing to this, I have felt myself obliged to relinquish the comparison of the land and fresh-water mollusca of Sicily with those of other countries, but I have done so the rather, and confined myself to the marine mollusca, because these latter alone have reference to the fossils of the tertiary period. Unfortunately we possess, from very few districts, even tolerably complete lists of the mollusca, and can rarely rely on the general works, such as those of

Gmelin and Lamarck, for the accurate statement of localities, so that the results obtained and recorded in this memoir concerning the geographical extension of the Mediterranean mollusca are necessarily very incomplete. Notwithstanding this, the publication of them will not, I hope, be thought superfluous; since a knowledge of the geographical extension of the mollusca is a matter far more important in reference to Geology than a similar knowledge concerning other classes of animals.

The fossil remains of mollusca must always be the main objects of investigation in researches concerning the age and history of the crust of our earth; and on their authority must be determined a multitude of important geological questions. It can hardly require proof that an acquaintance with the geographical extension of these animals at present, affords the only safe foundation for such researches concerning fossils; and I turn now at once to the results obtained by my own labours.

1. *Comparison of the Fauna of Greenland with that of South Italy.*

The "Fauna Groenlandiæ" of Otto Fabricius was long the only work on Greenland I could avail myself of; and up to the publication of my second volume of the "Enumeratio," I should have been obliged to limit myself to this as the only authority. Fabricius gives (from No. 381 to 427.) only forty-six species of shell-bearing mollusca, to which must be added two Cephalopoda, a Doris, an Æolis, and the *Clio borealis* (the *Ascidia*, which I have also omitted in the "Enumeratio," not being counted). Very lately, however, a complete catalogue of the Greenland mollusca has appeared from M. H. P. C. Möller (*Index Molluscorum Groenlandiæ. Hafniæ, 1842*). Of the mollusca there enumerated, the following species are met with in the Mediterranean:

<i>Octopus granulatus.</i>	<i>Tellina fragilis L.</i>
<i>Arca minuta.</i>	<i>Saxicava arctica L.</i>
<i>Mytilus edulis L.</i>	<i>Teredo navalis.</i>

2. *Comparison of the Fauna of Great Britain with that of South Italy.*

Of no country is the fauna generally, and that of the mollusca in particular, better known than of Great Britain, although the hitherto standard works of Donovan, Montague, &c., are almost unknown on the Continent; and neither Lamarck nor Deshayes have generally used them. A very good outline of the English mollusca-fauna will be found in Fleming's "History of British Animals," Edin. 1828; and, although this author has often, and as if intentionally, made use of generic names in a sense quite different from that of the founder of the genus, I have found it easy, with the help of Montague, to identify the names.

The list enumerated by Fleming, compared with that which I have obtained from South Italy, stands as follows, according to the

rather curious arrangement which I have taken as the most convenient in making the comparison with fossil species.

	British.	South Italy.
Marine Bivalves - - -	198	188
Fresh-water ditto - - -	10	11
Brachiopoda - - -	5	10
Pteropoda* - - -	—	13
Naked marine Gasteropoda - - -	20	54
Conchiferous ditto ditto - - -	191	313
Land and fresh-water ditto - - -	93	186
Heteropoda - - -	—	6
Cephalopoda - - -	7	15
Cirrhopoda* - - -	—	18
	<hr/> 524 <hr/>	<hr/> 814 <hr/>

Or, abstracting from the Italian list the groups not given in Fleming, we have

	British.	South Italy.
Marine mollusca - - -	422	573
Land and fresh-water ditto - - -	103	197
	<hr/> 525 <hr/>	<hr/> 770 <hr/>

It appears from this result* that South Italy is, as might indeed have been expected, richer in point of species than the British Isles, and that the proportion is nearly 147 to 100. This proportion of course does not hold with respect to separate groups, and the bivalves are actually more numerous in Great Britain than in South Italy.

The following species are common to Great Britain and South Italy, namely—

Marine Bivalves.

<i>Teredo navalis</i> L.	<i>Pandora obtusa</i> Leach.
<i>Pholas dactylus</i> L.	<i>Osteodesma corruscans</i> Seac. ?
<i>candida</i> L.	(norvegicum ?)
<i>Solen vagina</i> L.	<i>Thracia pubescens</i> Leach.
<i>siliqua</i> L.	<i>Galeomma Turtoni</i> Sow.
<i>ensis</i> L.	<i>Saxicava arctica</i> L.
<i>legumen</i> L.	<i>Venerupis Irus</i> L.
<i>coarctatus</i> L.	<i>Psammobia vespertina</i> L.
<i>Solecurtus strigilatus</i> L.	<i>costulata</i> Turt.
<i>Panopæa Aldrovandi</i> Men.	<i>feroensis</i> L.
<i>Lutraria elliptica</i> Lam.	<i>Tellina donacina</i> L.
<i>Scrobicularia piperata</i> Gm.	<i>fabula</i> Gm.
<i>Mactra solida</i> L.	<i>tenuis</i> Mat. et Rack.
<i>stultorum</i> L. ?	<i>fragilis</i> L.
<i>Bornia seminulum</i> Ph. ?	<i>baltica</i> L.
(<i>Kellia rubra</i> Flem. ?)	<i>Diplodonta rotundata</i> Mont.
<i>Corbula nucleus</i> Lam.	<i>Lucina spinifera</i> Mont.

* It is remarkable that Fleming omits entirely Pteropoda, Cirrhopoda, and the genus Dentalium, and inserts the Pteropod *Odontidium rugulosum*, describing it as an Orthocera. The addition of the Pteropod makes the complete British list given by Fleming include 525 species.

- Lucina commutata* Ph.
 radula Lam.
 lactea Poli non L.
Donax complanata Don.*
Mesodesma donacilla Desh.
Cytherea Chione L.
 exoleta L.
 linctæ L.
Venus casina L.
 verrucosa L.
 fasciata Don.
 gallina L.
 undata Penn.
 radiata Broc.
 decussata L.
 aurea Matt. et Rack.
 lætæ Poli.
Cardium echinatum L.
 aculeatum L.
 tuberculatum L.
 lævigatum L.
 exiguum Gm.
 edule L.
 parvum Ph.
 (*fasciatum* Mont.?)
Isocardia cor L.
Arca Noæ L.
 navicularis Brg.
- Arca lactea* L.
 barbata L.
Pectunculus pilosus L.
 violascens?
 (*P. nummarius* Ang.?)
Nucula margaritacea Lam.
 minuta L.
Modiola discrepans Lam.
 barbata L.
 lithophaga L.
Mytilus edulis L.
Pinna rudis L.
 pectinata L.
Avicula tarentina Lam.
Lima subauricula Mont.
 tenera Turt.
Pecten jacobæus L.
 opercularis L.
 varius L.
 pusio Lam.
Ostrea depressa Ph.?
 (*parasitica* Flem.?)
Anomia Ehippium L.
 polymorpha Ph.
 margaritacea Poli.?
 (*squamula*.)
 aculeata Mont.

Fresh-water Bivalves.

- Cyclas cornea* L.
 lacustris Müll.
 calyculata Drap.
- Pisidium obliquum* Lam
 fontinale Drap.
Anadonta anatina L.

Brachiopoda.

- Terebratula vitrea* L.
- Terebratula caput serpentis* L.

Naked Marine Gasteropoda.

- Doris verrucosa* L.
 argus L.
 pseudo-argus Rapp.
 reticulata Schultz.?
Aplysia depilans L.
 punctata Cuv.
- Elysia viridis* Mont.?
 (identical with *Aphlysiopterus*
 neapolitanus D. Ch., accord-
 ing to Cautraïne).

Conchiferous Marine Gasteropoda.

- Chiton lævis* Penn.
 fascicularis L.
Patella vulgata L.?
Tissurella græca L.
Emarginula cancellata Ph.
Pileopsis ungarica L.
Calyptrea vulgaris L.
Bulla lignaria L.
- Bulla hydatis* L.
 truncatula Brg.
 truncata Adams.
Bullæa planciana Ph.
 punctata Ad.
Truncatella truncatula Drap.
Rissoa exigua Mich.
 fulva Mich.

* This is described as *D. trunculus* L., but those I have seen from the North Sea under this name are of a different species.

Rissoa alcathiscus *Mont.*
ventricosa *Desm. ?*
(labiosa Flem. ?)
Eulima polita *L.*
subulata *Don.*
Chemnitzia elegantissima *Mont.*
Chemnitzia pallida *Ph. ?*
(unica Angl. ?)
scalaris *Ph. ?*
(simillima Angl. ?)
Natica intricata *Don.*
subcarinata *Walk.*
Ianthina bicolor *Menke.*
Coriocella perspicua *L.*
Haliotis tuberculata *L.*
Tornatella tornatilis *L.*
Scalaria communis *Lam.*
Trochus granulatus *Born.*
conulus *L.*
crenulatus *Broc.*
striatus *L.*
rugosus *L. (Turbo). **
magus *L.*

Phasianella pulla *L.*
Turritella communis *Ris.*
Cerithium fuscatum *Costa. ?*
Cerithium perversum *Lam.*
lima *Brg.*
Pleurotoma gracile *Mont.*
attenuatum *Mont.*
septangulare *Mont.*
purpureum *Mont.*
lineare *Mont.*
Fusus echinatus *Sow. ?*
(muricatus Flem. ?)
Murex erinaceus *L.*
Chenopus pes pelecani *L.*
Cassis undulata *L.*
Buccinum reticulatum *L.*
ascanias *Brg.*
minimum *Mont.*
variabile *Ph. ?*
(Nassa ambigua Flem. ?)
Marginella lævis *Donov.*
Cypræa coccinella *Lam.*

Land and Fresh-water Gasteropoda.

Limax rufus *L.*
Testacella haliotideia *F. B.*
Vitrina pellucida *Müll.*
Succinea amphibia *Drap.*
Helix Pomatia *L.*
pisana *Müll.*
elegans *L.*
ericetorum *Müll.*
variabilis *Drap.*
carthusiana *Drap.*
aculeata *Müll.*
nitida *Müll.*
rupestris *Drap.*
crystallina *Müll.*
striata *Drap.*
rotundata *Müll.*
aspersa *Müll.*
arbustorum *L.*
nemoralis *L.*
hortensis *Müll.*
Bulimus acutus *Brg.*
obscurus *Müll.*
pupa *L.*

Achatina acicula *Müll.*
lubrica *Müll.*
Pupa muscorum *Müll.*
avena *Drap.*
antivertigo *Drap.*
pygmæa *Drap.*
pusilla *Müll.*
Balea perversa *L.*
Clausilia bidens *Müll.*
Cyclostoma elegans *Müll.*
Limnæus palustris *Müll.*
ovatus *Müll.*
minutus *Drap.*
Physa fontinalis *L.*
Planorbis marginatus *Drap.*
spirorbis *Müll.*
Valvata piscinalis *Müll.*
cristata *Müll.*
Paludina tentaculata *L.*
thermalis *L.*
Ancylus fluviatilis *Drap.*
lacustris *L.*

Cephalopoda.

Octopus vulgaris *Lam.*
Loligo vulgaris *Lam.*
sagittata *Lam.*

Sepiolo Rondeleti *Leach.*
Sepia officinalis *L.*

* *Dephinula calcar* of English naturalists, which is found very rarely on the English coast, appears to me to be the young of *Turbo rugosus*.

Great Britain therefore, compared with Sicily, gives —

	Absolute No. of Species.		No. of Species common.	Proportion of Species common.	
	British.	Sicilian.			
Marine Bivalves	198	188	84	or 42 per ct. Brit.	45 Sicil.
Fresh-water do.	10	11	6	60 "	54 "
Brachiopoda	5	10	2		
Naked marine Gas- teropoda	20	54	7	35 "	13 "
Conchiferous do. do.	191	313	56	29 "	18 "
Land and fresh- water do.	93	186	45	48 "	25 "
Cephalopoda	7	15	5		

It appears from the above table that (with the exception of the less numerous and therefore for purposes of comparison more doubtful Cephalopoda) the Bivalves exhibit the maximum analogy between this part of the faunæ of the two countries; that next to them come the land and fresh-water Gasteropoda, and last of all the marine Gasteropoda. It results therefore that *the geographical extension of the Mollusca bears an inverse ratio to their powers of locomotion*, and this is confirmed by the other comparisons and analogies about to be given. But I must not omit to remark that in the above comparison of the land and fresh-water Gasteropoda, there appear several species which I have not myself seen, but have included on the authority of the Sicilian conchologists, and that Professor Maravigna reproaches his countrymen with often giving foreign for indigenous species.

It is however to be observed, that not only is the number of Mediterranean species absolutely greater than that of Great Britain, but that the number of the genera, and also the extent and variety of types, is also much more considerable; and although, in my opinion, the boundary lines defining many genera are still vague and unphilosophical, I may, notwithstanding, give as sufficient proof of this difference the following tables: —

List of South Italian Genera not represented in Great Britain.

Clavagella	Idalia	Notarchus	Fasciolaria
Solenomya	Diphyllidia	Onchidium	Tritonium
Scacchia	Pleurobranchæa	Sigaretus Lam. non Cuv.	Ranella
Cardita	Umbrella	*Haliotis L.	Cassidaria
Chama	Tylodina	Siliquaria	Columbella
Spondylus	Crepidula	Fossarus	Mitra
Thecidia	Acera	Solarium	Ovula
Thetis	Gasteropteron	Cancellaria	Conus

* Haliotis is not met with on the actual coast of Great Britain, but belongs rather to the Channel Islands.

List of British Genera not represented in South Italy.

Xylophaga	Mya	Sphenea
Sanguinolaria	Cyprina	Ervilia
Lepton	Goodallia	Discina
Velutina	Skenea	Cyclostrema
Lacuna	Polycera	Tergipes
Montagua		

If we now look to the *Habitus* or the *Physiognomy* of the fauna, if I may so express myself, with reference to the species common to both, we find the difference between the two faunæ to be much more considerable than when we only judge from the mere number of the identical species. We see, for instance, that the commonest and most abundant of the British species are either entirely absent or extremely rare in South Italy, and the converse. As an instance, I may quote the following species belonging to the former class :—

Of Marine Mollusca.

Patella vulgata	Buccinum glaciale	Mactra (<i>several</i>)
pellucida	Fusus antiquus	Tellina punicea
virginea	despectus	bimaculata
Turbo littoreus	turricula	crassa
rudis	(Harpula Mencke)	Astarte (<i>several</i>)
obtusatus	Pleurotoma (<i>several species</i>)	Cyprina islandica
Trochus cinerarius		Pholas crispata
Purpura lapillus	Pecten maximus	Mya arenaria
Buccinum undatum	obsoletus	&c. &c.

Of Land and Fresh-water Species.

Limax agrestis	Clausilia rugosa	Planorbis contortus
Helix pomatia	plicatula	vortex
arbustorum	Lymnaeus auricularius	Paludina vivipara
hortensis	Physa hypnorum	Unio batavus
nemoralis	Planorbis corneus	&c.

On the other hand, the following common South Italian species are either quite absent or very rare in Great Britain :—

Of Marine Species.

Tellina pulchella	Lima inflata	Trochus fragarioides
depressa	squamosa	divaricatus
nitida	Pecten jacobæus	fanulum
Lucina pecten	polymorphus	canaliculatus
Donax trunculus	hyalinus	Richardi
venusta	Spondylus gæderopus	umbilicaris
Venus geographica	Chiton siculus	Adansonii, &c
Cardium erinaceum	Patella (<i>almost every sp.</i>)	Monodonta Vicilloti
sulcatum	Bulla striata	Jussieui
papillosum	Nerita viridis	Phasianella speciosa
Cardita (<i>all the species</i>)	Natica olla	Turbo neritoides L.
Chama gryphoides	millepunctata	(cærulescens Lamk.)

Cerithium vulgatum	Murex brandaris	Buccinum mutabile
Fasciolaria lignaria L.	trunculus	corniculum
(tarentina Lamk.)	cristatus	d'Orbigny
Fuscus corneus L.	Edwardsii	pusio L.
(lignarius Lamk.)	Triton (<i>every species</i>)	neriteum
Syracusanus	Cassidaria	Columbella rustica, &c.

Of Land and Fresh-water Species.

Helix aperta	Helix strigata	Bulimus decollatus
vermiculata	pyramidata	Achatina folliculus
candidissima	conica	Paludina rubens, &c.
globularis	conoidea	

3. *Comparison of the Fauna of the Canary Islands with that of South Italy.*

In the work by Webb and Berthelot on the Canary Islands (concerning which it is only to be lamented that the book is too luxurious and expensive for private persons to be able to purchase it, and that thus a great part of its value in a scientific sense is lost), we find only 196 species of Mollusca enumerated, of which the following occur in South Italy.

Marine Bivalves.

Saxicava arctica L.	Pectunculus pilosus L.
Psammobia vespertina L.	Modiola costulata Riss.
Lucina lactea Poli.	Chama gryphoides L.
pecten Lam.	Pinna rudis L.
Donax trunculus L.	Avicula tarentina Lamk.
Venus verrucosa L.	Lima inflata Lamk.
Cardium tuberculatum L.	squamosa Lam.
edule L.	Pecten jacobæus L.
Cardita calyculata Brg.	pusio Lam.
corbis Ph.	Spondylus Gæderopus L.
Arca Noë L.	Ostrea cochlear Poli.
imbricata Poli.	

Fresh-water Bivalves.

None.

Brachiopoda.

Terebratula truncata L.

Pteropoda.

Hyalæa tridentata Lam.	Cleodora cuspidata Q. et G.
gibbosa Rang.	acicula Rang.
trispinosa Lesueur.	

Naked Marine Gasteropoda.

None.

Conchiferous Marine Gasteropoda.

Chiton fascicularis <i>L.</i>	Cerithium perversum <i>Lam.</i>
Patella cærulea <i>L.</i>	Murex brandaris <i>L.</i>
Emarginula elongata <i>Costa</i>	trunculus <i>L.</i>
Chemnitzia elegantissima <i>Mont.</i>	Tritonium nodiferum <i>L.</i>
Eulima distorta <i>Desh.</i>	scrobiculator <i>L.</i>
Ianthina bicolor <i>Menke.</i>	cutaceum <i>L.</i>
nitens <i>Menke.</i>	Cassis undulata <i>L.</i>
Haliotis tuberculata <i>L.</i>	Dolium galea <i>L.</i>
Scalaria pseudo-scalaria <i>Broc.</i>	Purpura hæmastoma <i>L.</i>
Trochus fragarioides <i>Lam.</i>	Buccinum mutabile <i>L.</i>
Richardi <i>Payr.</i>	reticulatum <i>L.</i>
Magus <i>L.</i>	Columbella rustica <i>L.</i>
rugosus <i>L. (Turbo)</i>	Mitra Ebenus <i>Lam.</i>
Phasianella pulla <i>L.</i>	Ringicula auriculata <i>Men.</i>
Turritella triplicata <i>Broc.</i>	Cypræa lurida <i>L.</i>
Cerithium vulgatum <i>Brg.</i>	pyrum <i>L.</i>
Lima <i>Brg.</i>	spurea <i>L.</i>

Land and Fresh-water Mollusca.

Testacella haliotidea <i>F. B.</i>	Bulimus ventricosus <i>Drap.</i>
Helix pisana <i>Müll.</i>	pupa <i>L.</i>
cellaria <i>Müll.</i>	decollatus <i>L.</i>
maritima <i>Drap.</i>	Cyclostoma elegans <i>Müll.</i>
lenticula <i>Fer.</i>	Physa fontinalis <i>L.</i>

Cephalopoda.

Octopus vulgaris <i>Lam.</i>	Loligo vulgaris <i>Lam.</i>
ruber <i>Rap.</i>	Sepia officinalis <i>L.</i>

The following table shows the number of species of Mollusca in the different groups of the fauna of the Canary Islands, and the number and proportion of species found also in Sicily:—

	Absolute No. of Species.		Spec. common to the two localities.	Proportion of species common to both.	
	Canaries	Sicily.			
Marine Bivalves	34	188	23	68 per ct.	Canaries 13 Sicil.
Brachiopoda	1	10	1		
Pteropoda	16	13	5	34	„ 38 „
Naked marine Gas- teropoda	5	54	0		
Conchiferous do. do.	73	313	34	46½	„ 11 „
Land and fresh- water do.	59	186	10	17	„ 5 „
Cephalopoda	8	15	4	„	26 „

Among the groups of Mollusca represented by the largest number of species, the bivalves again exhibit more species in common than the marine Gasteropoda. The resemblance between the land and fresh-water Gasteropoda of the two districts is very slight, most of the Canary Island species being confined to that locality, obeying the same law according to which the plants of islands far removed from any continent are generally peculiar and elsewhere unknown. Since the number of land mollusca in the Canary Islands is so

limited, and that of the fresh-water tribes is almost entirely absent, we ought not to wonder, although it appears scarcely credible, that the list of the marine inhabitants is so small as we find it recorded.

There are, comparatively, but few genera adorning the shores of the Canary Islands which are absent in South Italy: among them, however, are *Voluta*, *Terebra*, and *Crassatella*, and the tropical genus *Conus* is already represented by four species out of seventy-three (the whole number of marine Gasteropoda), although other tropical genera *Nerita* (in its limited sense), *Strombus*, *Pterocera*, *Tridacna*, &c., are not yet met with.

It may be remarked, that many of the commonest South Italian species are absent in the Canaries; as, for instance, all the *Solens*, all the *Tellinæ*, *Cytheræa* *Chione* and *exoleta* (the latter re-appearing in Senegal); *Venus decussata*, *geographica*, *gallina*; *Cardium echinatum*, *aculeatum*, *erinaceum*, *papillosum*; almost all the *Pectens*, all the *Anomias* (not a single species described); every species of *Fissurella*, *Calyptræa*, *Crepidula*, and *Rissoa* (one species of *Rissoa* is described); all the *Naticas* and *Vermetus* (not one of this latter being known); *Trochus granulatus*, *Conulus*, *crenulatus*, *striatus*, *divaricatus*, *fanulum*, *umbilicaris*; *Phasianella speciosa*; *Turbo neritoides* (L. non auct.); *Pleurotoma*; *Fusus* (not one species of either mentioned); *Murex erinaceus*, *cristatus*, *Edwardsii*; *Tritonium corrugatum*; *Chenopus pes pelicani*; *Cassidaria*; *Buccinum variabile*, *d'Orbigny*, *corniculum*, *neriteum*, *pusio* L., *scriptum* L.; *Cypræa coccinella*; *Conus mediterraneus*; *Helix naticoides*, *aspera*, *vermiculata*, *strigata*, *variabilis*; *Clausilia* (not one species appearing to inhabit the islands).

4. Comparison of the Fauna of Senegal with that of South Italy.

Adanson has given a list of the mollusca of Senegal in his admirable and well-known work, but this list is very incomplete and enumerates only 196 species, the same number, it will be observed, as that obtained from the Canary Islands. This incompleteness is the more to be lamented, because a number of the species enumerated by him are new and still without systematic names, notwithstanding that his countrymen have remained for a century in undisturbed possession of the district traversed by him. It appeared to me of great consequence, however, to determine which of the Mediterranean species extended to Senegal, and I have therefore myself endeavoured to make out this so far as the figures and descriptions would enable me to do it. The following tables are the result of this endeavour to attain my object:—

Marine Bivalves.

<i>Teredo navalis</i> L., Taret.	<i>Cytherea exoleta</i> L., Cotan.
<i>Solen legumen</i> L., Molan.	<i>Venus verrucosa</i> L., Clonisse.
<i>Solecurtus strigilatus</i> L., Golar.	<i>decussata</i> L., Lunot.
<i>Donax trunculus</i> L., Gafet.	<i>Pectunculus pilosus</i> L. ? Vovan.
<i>Lutraria piperata</i> Gm., Calcinelle.	<i>Spondylus Gæderopus</i> L., Guron.

Conchiferous Marine Gasteropoda.

<i>Bulla striata</i> Brg., Gosson.	<i>Trochus fragarioides</i> Lam., Osilin.
<i>Fissurella græca</i> L. ?, Gival.	<i>Monodonta corallina</i> L., Fuget.
<i>Crepidula unguiformis</i> Lam., Garn.	<i>Cerithium vulgatum</i> Brg., Goumier.
<i>Haliotis tuberculata</i> L., Ormier.	<i>Cancellaria cancellata</i> L., Bivet.
<i>Sigaretus haliotideus</i> L., Sigaret.	<i>Purpura hæmastoma</i> L., Sakem.
<i>Natica millepunctata</i> Lam., Fanel.	<i>Cassis Saburon</i> Lam., Saburon.
<i>Fossarus Adansonii</i> Ph., Fossar.	<i>Columbella rustica</i> L., Siger.
<i>Trochus magus</i> L., Dalat.	<i>Mitra lutescens</i> Lam., Gousol.
<i>umbilicaris</i> L., Lonier.	<i>Cypræa lurida</i> L., Pucelage D.

Adanson does not mention any naked mollusca, and only two species of land and fresh-water shells.

Of 58 marine Bivalves of Senegal there are in South Italy 10 or 17 per cent.

131 conchiferous Gasteropoda - - - 18 or 14 -

Here also, therefore, it is observable that a greater analogy holds between the Bivalves of the two regions than between the Gasteropoda.

The fauna of Senegal is much more different than that of the Canary Islands from the fauna of the Mediterranean. This last has 68 per cent. of its bivalves common to both, and the Senegal only 17, while the Canaries have 47 per cent. of the gasteropoda, and Senegal only 14 per cent. common. In the latter region, we find several species of *Voluta*, *Terebra*, *Strombus*, *Nerita* (in its limited sense); and still more numerous are the examples of *Conus*, *Cypræa*, *Marginella*, *Ostrea*, &c., and it is especially remarkable that one solitary and very small species of *Pecten* is enumerated by Esson, but is yet undescribed.

5. Comparison of the Fauna of the Red Sea with that of South Italy.

In the year 1834 I arranged and described, at the request of Professor Ehrenberg, the shells collected in the Red Sea and its vicinity by Messrs. Von Hemprich and Ehrenberg, but the publication of the results has been, up to this time, delayed. The information thus derived has served as the groundwork of the following comparative tables. The Red Sea has in common with South Italy:—

Marine Bivalves.

<i>Solen vagina</i> L.	<i>Arca Noæ</i> L.
<i>legumen</i> L.	<i>tetragona</i> Poli.
<i>Mactra stultorum</i> L.	<i>barbata</i> L.
<i>inflata</i> Bronn.	<i>diluvii</i> Lam.
<i>Corbula revoluta</i> Broc.	<i>Pectunculus violacescens</i> Lam.
<i>Diplodonta rotundata</i> Mont.	<i>Nucula margaritacea</i> Lam.
<i>Lucina lactea</i> Poli.	<i>Chama gryphoides</i> L.
<i>pecten</i> Lam.	<i>Modiola discrepans</i> Lam.
<i>Mesodesma donacilla</i> Desh.	<i>Petagnæ</i> Scac.
<i>Donax trunculus</i> L.	<i>lithophaga</i> L.
<i>Venus verrucosa</i> L.	<i>Pinna squamosa</i> L.
<i>decussata</i> L.	<i>nobilis</i> L.
<i>Cytherea exoleta</i> L.	<i>Spondylus aculeatus</i> Chemn.
<i>lineta</i> Lam.	<i>Ostrea cristata</i> Born.
<i>Cardita calyculata</i> Brg.	

There are, from the Red Sea and its neighbourhood, no fresh-water Bivalves, no Brachiopoda, only one Pteropod is mentioned (*Odontidium rugulosum*), although I possess *Hyalæa quadridentata* and *H. longirostris* from the same locality, and no naked marine gasteropoda.

Land and Fresh-water Gasteropoda.

Succinea Pfeifferi Ross.
Helix pisana Müll.
 striata Drap.

Helix lenticula Fer.
Paludina rubens Menke.
 thermalis L.

Marine Gasteropoda.

Patella cærulea L.
 lusitanica Gm.
 tarentina Lam.
 fragilis Ph.
Fissurella græca L.
 costaria Desh.
 rosea Lam.
Bulla striata Brg.
 truncata Adams.
Eulima polita L.
Chemnitzia elegantissima Mont.
Truncatella truncatula Drap.
Rissoa glabrata V. Mühlf.
Natica olla M. de Serr.
 millepunctata Lam.
Nerita viridis L.
Ianthina bicolor Menke.
Haliotis tuberculata L.
Tornatella tornatilis L.
Trochus crenulatus Broc.
 striatus L.
 Adansonii Pay.

Trochus varius Gm.
Cerithium vulgatum Brg.
 mammillatum Riss.
 Lima Brg.
 perversum Brg.
Fasciolaria lignaria L.
Fusus corneus L.
 syracusanus L.
 rostratus Olivi.
Murex trunculus L.
Tritonium variegatum Lam.
Ranella lanceolata Mke.
Dolium Galea L.
Buccinum variabile Ph.
 mutabile L.
 gibbosulum L.
Mitra lutescens Lam.
Marginella clandestina Broc.
 miliacea L.
 minuta P. S.
Cypræa moneta L.
 erosa L.

Cephalopoda.

Octopus vulgaris.

On the whole, the following table exhibits the relative state of the Red Sea and South Italian fauna.

	Red Sea Species.	Sicilian Species.	No. of Species common.	Proportion of Species common to both.	
Marine Bivalves	127	187	29	or 23 per ct. of	16 per ct.
Fresh-water do.	5	11	0	Red Sea spec.	of Sicil.
Pteropoda	3	13	1		spec.
Naked marine } Gasteropoda }	23	54	0		
Conchiferous do. do.	248	313	44	18 „	14 „
Land and fresh- } water do. }	30	186	5	16 „	2 „
Cephalopoda	7	15	1		
Cirrhopoda	10	18	3		16 „

This result shows that the Red Sea fauna has a greater analogy with that of the Mediterranean than the Senegal fauna. The latter has 17, and the former 23 species of marine bivalves common

to both, and 18 instead of 14 per cent. of marine Gasteropoda marks a similar approximation. But here also the general law still holds, of the Bivalves being more widely distributed than the Gasteropoda.

If we glance at the physiognomy of the fauna as before, the difference is found to be even greater than could be supposed from the numbers. The following Sicilian genera, for instance, are absent in the Red Sea:—

<i>Teredo</i>	<i>Thracia</i>	<i>Anomia</i>	<i>Chenopus</i>
<i>Pholas</i>	<i>Mesodesma</i>	<i>Crepidula</i>	<i>Cassidaria</i>
<i>Solenomya</i>	<i>Astarte</i>	<i>Coriocella</i>	
<i>Pandora</i>	<i>Isocardia</i>	<i>Siliquaria</i>	

And, on the other hand, the following found in the Red Sea do not appear in the Mediterranean; namely—

<i>Aspergillum</i>	<i>Crenatula</i>	<i>Nerita</i> (in its limited sense)	<i>Ancillaria</i>
<i>Sanguinolaria</i>	<i>Perna</i>	<i>Ampullaria</i>	<i>Harpa</i>
<i>Anatina</i>	<i>Vulsella</i>	<i>Melania</i>	<i>Ricinula</i>
<i>Cyrene</i>	<i>Malleus</i>	<i>Melanopsis</i>	<i>Terebra</i>
<i>Tridacna</i>	<i>Plicatula</i>	<i>Pyramidella</i>	<i>Turbinella</i>
<i>Crassatella</i>	<i>Pedum</i>	<i>Oliva</i>	<i>Strombus</i>
<i>Aetheria</i>	<i>Siphonaria</i>		<i>Pterocera</i>

It is also universally the case, that the genera which in Sicily are rich in number of species, in the Red Sea have very few and the converse.

In the Red Sea are—

<i>Chama</i> 5	<i>Cypræa</i> 16
<i>Pinna</i> 10	<i>Mitra</i> 10
<i>Ostrea</i> 11	<i>Terebra</i> 6
<i>Nerita</i> 4	<i>Cerithium</i> 17
<i>Conus</i> 19	<i>Strombus</i> 8

In Sicily—

<i>Chiton</i> 8
<i>Natica</i> 10
<i>Trochus</i> 27
<i>Pleurotoma</i> 18
<i>Buccinum</i> 28

It will not now seem extraordinary that the species which in Sicily are most common are absent in the Red Sea. As examples, we have

<i>Solen siliqua</i>	<i>Pectens</i> (<i>all</i>)	<i>Turbo neritoides</i> <i>L.</i>
<i>Tellina pulchella</i>	<i>Anomia</i> (<i>all</i>)	<i>Murex brandaris.</i>
<i>donacina</i>	<i>Pileopsis hungarica</i>	<i>erinaceus</i>
<i>planata</i>	<i>Crepidula unguiformis</i>	<i>tarentinus</i>
<i>tenuis</i>	<i>Bulla hydatis</i>	<i>cristatus</i>
<i>depressa</i>	<i>Rissoa</i> (<i>almost all</i>)	<i>Edwardsii</i>
<i>Donax venusta</i>	<i>Natica millepunctata</i>	<i>Buccinum d'Orbigny</i>
<i>Cytherea chione</i>	<i>intricata</i>	<i>corniculum</i>
<i>Venus gallina</i>	<i>Scalaria communis</i>	<i>neriteum</i>
<i>geographica</i>	<i>Trochus granulatus</i>	<i>pusio</i> <i>L.</i>
<i>Cardium</i> (<i>all</i>)	<i>cornulus</i>	<i>scriptum</i> <i>L.</i>
<i>Cardita sulcata</i>	<i>fragarioides</i>	<i>Columbella rustica</i>
<i>Isocardia cor</i>	<i>rugosus</i>	<i>Cypræa lurida</i>
<i>Pectunculus pilosus</i>	<i>fanulum</i>	<i>pyrum</i>
<i>Modiola barbata</i>	<i>magus</i> *	<i>coccinella, &c.</i>
<i>Myrtilus edulis</i>	<i>Monodonta Vieilloti</i>	
<i>Lima inflata</i>	<i>Jussieui</i>	

* The shell that has been thought to be this is the very different *Trochus erythraeus* Broc.

Of the Bivalves, the greater number of the Red Sea species belong to the division *unimusclosa*.

6. *Comparison of the Fauna of the Sechelle and Admiralty Islands with that of South Italy.*

M. Dufo has given (in the Ann. des Sc. Nat. 2d Ser. vol. xiv. for 1840.) a list of the mollusca of these islands, enumerating 276 species, namely, 220 conchiferous marine gasteropoda, 11 land gasteropoda, 2 fresh-water gasteropoda, and 43 marine bivalves. Since the smaller species throughout, and all the cephalopoda, pteropoda, brachiopoda, and naked gasteropoda are omitted, this catalogue can of course give but a very imperfect view of the fauna, but notwithstanding this I have thought it better to bring it within the sphere of my observations. Of the 276 species, we find the following nine in the Mediterranean:—

Modiola lithophaga L.	Cypræa annulus L.
Lima squamosa Lam.	moneta L.
Bulla ampulla L.	helvola L.
Ianthina fragilis Lam.	Dolium Galea L.
Tornatella tornatilis L.	

But of these the *Bulla ampulla* and all the Cyprææ belong to the very rarest of the mollusca, indigenous in the Mediterranean, and they must even be considered doubtful.

7. *Comparison of the Fauna of the United States with that of South Italy.*

It is unquestionably a very important point to discover how far the Atlantic Sea, as it separates the Flora and Fauna of the land, nourishes different mollusca on its eastern and western shores. Unfortunately, however, I have found it impossible to obtain even the most necessary materials for such comparison.

My only authorities have been the "Journal of the Academy of Natural Sciences of Philadelphia," vols. i. ii. and v.; and "Say's American Conchology," as far as plate 50. The American edition of Nicholson's Encyclopædia and the remaining volumes of the Philadelphian Journal I have not been able to obtain; and, unluckily, the collections of shells which I have received from my North American friends, Messrs. Lee, Morris, and Griffith, are very poor in marine species. The following European species are, however, found in the United States:—

- *Mya arenaria L. (M. mercenaria Say)
- Scrobicularia piperata Gm. (Amphidesma transversum Say)
- *Cyprina islandica L.
- Achatina lubrica L.
- Helix fulva Müll. (H. chersina Say)
- pulchella Müll. (H. minuta Say)
- *Paludina vivipara L.
- porata Say

* *Paludina thermalis* L. (I have received two different species under the name *Turbo minutus* Say, the smaller of which I cannot distinguish from *P. thermalis*.)

Crepidula unguiformis Lam. (*C. plana* Say)

Scalaria communis Lam.? (In North America appears a small white variety, which may be another species)

* *Buccinum undatum* L.

* *Purpura lapillus* L.

Of these species, those marked (*) are not found in the Mediterranean. The above list contains, however, certainly but a small part of the species common to the two hemispheres; for Say, in his American Conchology, in speaking of *Paludina vivipara*, observes, "this appears to be one of several species common to North America and Europe."

8. Comparison of the Cuba Fauna with that of South Italy.

For obtaining this comparison I have availed myself partly of Pfeiffer's Catalogues, containing 289 species (Archiv. for 1839, p. 346., and 1840, p. 250.), and partly of D'Orbigny's, in Ramon de la Sagra's "Hist. Physique, &c., de l'Isle de Cuba," which latter, however, I have only been able to refer to as far as No. 293. Two or three species I have been able to add which my brother, E. B. Philippi, collected at Matanzas in 1835.

The species in the following list, whose presence in the Mediterranean is doubtful, are marked thus (†):—

<i>Lucina pecten</i> Lam.?	<i>Truncatella truncatula</i> Drap.
<i>Arca Noë</i> L.	<i>Chemnitzia elegantissima</i> Mont.
<i>Pectunculus marmoratus</i> L.	† <i>Nerita versicolor</i> Gm.
<i>Chama gryphoides</i> L.	<i>viridis</i> L.
<i>Modiola tulipa</i> Lam.	<i>Ianthina bicolor</i> Menke.
<i>discrepans</i> Lam.	<i>nitens</i> Mke.
<i>lithophaga</i> L.	<i>Sigaretus haliotideus</i> L.?
<i>Pinna pectinata</i> L.	† <i>Trochus carneolus</i> Lam.
<i>Lima squamosa</i> Lam.	† <i>hippocastanum</i> Lam.
<i>Pecten gibbus</i> L.	† <i>Turbo muricatus</i> L.
<i>Hyalæa tridentata</i> Gm.	<i>Phasianella speciosa</i> V. Mühlf.
<i>trispinosa</i> Les.	<i>Cerithium vulgatum</i> Brg.
<i>Cleodora lanceolata</i> Péron.	<i>perversum</i> Brg.
<i>cuspidata</i> Rang.	<i>trilineatum</i> Ph.
<i>spinifera</i> Rang.	<i>Tritonium variegatum</i> Lam.
<i>striata</i> Rang.	<i>Pleurotoma attenuatum</i> Mont.
<i>acicula</i> Rang.	<i>cinctellum</i> Pf.?
<i>Odontidium rugulosum</i> Ph.	<i>Marginella minuta</i> Pf.
<i>Fissurella græca</i> L.	<i>Cypræa annulus</i> L.
<i>costaria</i> Desh.?	<i>Octopus ruber</i> Raf.
<i>Crepidula unguiformis</i> Lam.	<i>vulgaris</i> Lam.
<i>Bulla striata</i> Brg.	<i>Atlanta Peronii</i> Les.
<i>Physa acuta</i> Drap.	

The materials here are too incomplete to admit of any accurate proportion being deduced; but I would observe that the number of

species common to the Antilles and the Mediterranean is unexpectedly large.

I will take this opportunity of correcting an error into which D'Orbigny has fallen, before the mischief spreads further. M. d'Orbigny observes, "Nous réunissons dans la famille des Trochoides les Mollusques gastéropodes, dont le principal caractère est, d'avoir le dessus du pied pourvu latéralement des filets tentaculiformes plus ou moins nombreux. Nous les divisons ainsi qu'il suit :—

Sans appendices à la base interne des tentacules, un opercule corné	{ Trochus Rotella Solarium Delphinula Phorus ?
Des appendices à la base interne des tentacules, un opercule pierreux	{ Turbo Phasianella"

The truth of the matter is, that Trochus and the other genera with a horny operculum exhibit the "*appendices à la base interne des tentacules*" quite as well, and of as large a size, as Turbo and Phasianella; and if M. d'Orbigny thinks this is not the case, he cannot have observed the animal properly. I have found it very beautifully shown in all the fifteen species of Trochus of which I have either drawn the living animal, or preserved it in spirits; and I can, therefore, only conclude that this statement of D'Orbigny, and Quoy and Gaimard, is the result of imperfect observation.

9. *Comparison of the Fauna of the West Coast of New Holland with that of South Italy.*

If we refer to the catalogue of 260 species of Mollusca collected by Preiss on the west coast of New Holland, and described by Menke in the "Specimen Molluscorum Novæ Hollandiæ," we shall find the following species, which also appear in the Mediterranean.

Lutraria solenoides *Lam.*
Mactra helvacea *Chemn.*
Arca tetragona *Poli.*
Modiola lithophaga *L.*
Lima squamosa *Lam.*
Bulla striata *Brg.*

Succinea oblonga *Drap.*
Paludina thermalis *L.*
Mitra lutescens *Lam.*
Cypræa annulus *L.*
moneta *L.*

I append in conclusion a table of those Mediterranean species which, according to my researches, have very wide geographical extension.

	Medi- terra- nean.	Green- land.	Brit. Isles.	Canary Islands.	Sene- gal.	Red Sea.	Sechelle and Admiralty Islands.	U.S.	Cuba.	W. Coast of New Holland.
<i>Solen legumen L.</i>	—		—		—	—				
<i>vagina L.</i>	—		—		—	—				
<i>Solecurtus strigilatus L.</i> ...	—		—		—					
<i>Scrobicularia piperata Gm.</i> ..	—		—					—		
<i>Saxicava arctica L.</i>	—	—	—	—						
<i>Psammobia vespertina L.</i> ...	—		—	—						
<i>Diplodonta rotunda Montf.</i> ..	—		—			—				
<i>Lucina lactea Poli.</i>	—		—	—		—				
<i>Donax trunculus L.</i>	—		—	—	—	—				
<i>Cytherea exoleta L.</i>	—		—	—	—	—				
<i>Venus verrucosa L.</i>	—		—	—	—	—				
<i>decussata L.</i>	—		—	—	—	—	—			
<i>Cardium echinatum L.</i>	—	—	—							
<i>Arca Noë L.</i>	—			—	—?	—			—	
<i>Pectunculus pilosus L.</i>	—		—	—	—				—	
<i>Chama gryphoides L.</i>	—		—	—		—			—	
<i>Mytilus edulis L.</i>	—	—	—							
<i>Modiola lithophaga L.</i>	—		—			—	—		—	—
<i>Pecten jacobæus L.</i>	—		—	—					—	
<i>Lima squamosa Lam.</i>	—		—	—			—		—	—
<i>Spondylus gæderopus L.</i> ...	—		—	—	—					
<i>Chiton fascicularis L.</i>	—		—	—						
<i>Fissurella græca L.</i>	—		—	—	—	—			—	
<i>Crepidula unguiformis Lam</i> ..	—		—	—	—	—			—	
<i>Bulla striata Brg.</i>	—		—	—	—				—	— and N. Zealand. — Do.
<i>Paludina thermalis L.</i>	—	Baltic	—			Libya.		—		
<i>Chemnitzia elegantissima</i> } <i>Montf.</i>	—		—	—		—			—	
<i>Ianthina bicolor Mke.</i>	—		—	—		—	—?		—	
<i>Haliotis tuberculata L.</i>	—		—	—	—	—			—	
<i>Tornatella tornatilis L.</i>	—		—	—	—	—	—			
<i>Trochus magus L.</i>	—		—	—	—	—				
<i>Cerithium vulgatum L.</i>	—		—	—	—	—			—	
<i>perversum Brg.</i>	—		—	—		—			—	
<i>Lima Brg.</i>	—		—	—		—			—	
<i>Dolium Galea L.</i>	—		—	—		—	— and Philippines.			
<i>Cypræa annulus L.</i>	—?						—		—	— and Tonga-tabu.
<i>moneta L.</i>	—?					—	—			— Do.

D. T. A.

II. *On the FOSSILS of the PYRENEES.* By M. DESHAYES, Vice-President of the Geological Society of France.

[Read before the French Geological Society, June 17. 1844.]

It has been established since the year 1830, as one of the results of my investigations on the distribution of fossils in the tertiary formations of Europe, that there exists no one species common to the cretaceous and tertiary rocks, and at the period alluded to I had already arrived at the opinion that all the cretaceous species were destroyed before the commencement of the tertiary period. I have since defended this view, although it is opposed to that held by many geologists, and particularly to certain observations offered in the memoirs of the authors of

the beautiful geological map of France. These geologists observed in the South of France beds of considerable thickness, in which they have professed to find tertiary fossils mingled with cretaceous species, and this supposed mixture occurs, not between the newest cretaceous bed and the oldest tertiaries, but between these last and comparatively ancient beds of the cretaceous group. Being in possession of a very considerable number of facts, which satisfied me that there were no species common to the chalk and the tertiary strata, and knowing also the observations of Messrs. Dufresnoy and Elie de Beaumont, I waited till further investigations should throw some light on the question. I further objected that it was not in the Pyrenees, where the upper member of the cretaceous group is wanting, that the problem could be solved, but rather in those districts where the chalk, in its most complete form, is in immediate contact with the most ancient tertiary beds. Now it is at Maestricht that this sequence is found, and it has long been affirmed positively that in this well-known locality no species occurs common to the newest cretaceous rocks and the oldest tertiaries of the period of the Paris Basin. If the mixture of species is not to be found there, where the nearest approach is made to a perfect sequence, then, *à fortiori*, we can still less expect to find it in a district where the chronological order of the formations is interrupted by the absence of the upper cretaceous beds of Maestricht.

Till lately, however, the question has been left undetermined in geology, and it was necessary to examine afresh the formations in which the mixture of species had been observed. Our colleague, M. Leymerie, has already given to the Society the result of his conscientious and laborious researches: he has submitted for your examination collections of fossils richer than any hitherto known, and among all the species he has collected, he has not found one common to the tertiaries and the cretaceous rocks. Mr. Pratt, a careful observer, who is known to you by his papers on geological subjects, and who is fully aware of the importance of this matter, not being satisfied with the result of a first journey to Biarritz, has undertaken another this year, and it is the result of this second excursion that our excellent colleague has charged me to communicate to the Society. Before his departure, Mr. Pratt was impressed with the necessity of observing with the greatest attention the boundary line between the tertiary beds and the chalk: he knew also that it would not be sufficient to collect the fossils at the foot of the escarpments, but that he must take them from the beds themselves, and that he must keep his collections distinct. The groups of fossils procured by Mr. Pratt under these circumstances seem to me to possess great importance, and I have examined them with the most careful attention: the result of this examination has been, first, that the whole of the nummulitic system belongs to the tertiary series, which confirms the observations of M. Leymerie in the Corbières

and of M. Bertrand Geslin in the Alps ; and next, that the species collected by Mr. Pratt, although belonging to the lower tertiary strata, are, for the most part, different from those of M. Leymerie. It appears indeed that the analogues of the species collected by the latter gentleman occur in the beds of the Soissonnais, while those of Mr. Pratt are most nearly analogous to the *calcaire grossier* species properly so called ; and it results from the comparison of Mr. Pratt's fossils with those of the cretaceous rocks, that there are two species perfectly identical. One of these belongs to the genus *Spondylus*, and has been described under the name of *Plagiostoma spinosa*. It occurs, as is well known, in the upper chalk, and it is worthy of remark that it appears to be absent in the more recent cretaceous rock of Maestricht. The other species, common to the chalk and the tertiaries, is a singular coral which M. Michelin, in his work on fossil corals, has referred to the genus *Guettardia*. It is the *G. stellata*, the sixth variety in plate 30 of the work just quoted. This coral appears in the chloritic (lower) chalk, and in the upper or white chalk, but, like the *Plagiostoma*, appears to be absent in the uppermost chalk of Maestricht. Thus, it is now determined that there are in a tertiary bed two fossil species which existed during the cretaceous period, and both of them present the singular phenomenon of passing at once from an inferior cretaceous rock to the tertiaries without occurring in the intermediate formations.

My object at present is not to consider whether the two species in question lived at the same time as the tertiary species. To decide this, it would be necessary to examine them in their relation to the beds with which they are associated, to estimate their abundance, and to see, by the state of preservation of all the specimens, whether they are actually *in situ*,—matters impossible to judge of from the small number of specimens collected by Mr. Pratt.* One might fairly enquire whether the mixture may not have been made in the same manner as that which operates daily in the Channel, where the fossil species washed into the sea by the degradation of the cliffs become associated with the remains of the species actually living in the neighbouring sea.

The facts which I have just communicated to the Society naturally afford an opportunity of answering certain objections made by those geologists who reject the conclusions of zoologists as applied to their science. These objections consist in the pre-

* I am informed by Mr. Pratt, with reference to the doubts thrown by M. Deshayes on the two fossils common to the cretaceous and tertiary beds, that they were found in great abundance—that the specimens exhibited every stage of growth—and that they occurred in several of the tertiary beds throughout a thickness of 400 or 500 feet (the whole thickness of the tertiary deposit being above 2000 feet). It is remarkable also that the *Spondylus* (*Plagiostoma spinosa*) is found in the newer and the coral in the middle part of the tertiaries.

Besides the two species alluded to by M. Deshayes, the *Terebratula striata* of the chalk and greensand has also been found by Mr. Pratt, and this fossil, like the others, is extremely abundant. — ED.

tending that when certain species are troublesome to zoologists, they unite them as varieties, separate them into distinct species, or declare them new, in order to make their distribution agree with a pre-established division of formations; so that, acting in this way, (it is said) the Palæontologists turn their science into a convenient system, always ready to adapt itself to all phases of observations, since the determination of fossil species, on which the most important results of the application of Zoology depend, is guided by no fixed principles, and seems exposed to the caprice of every observer.

If the works of some Palæontologists have deserved these objections, no such reflection can be cast on the general application of Zoology to Geology; and I may safely say, that my own works, known to the Society, are exempt from this reproach of uncertainty which is frequently applied to Palæontology; and I believe that all the comparisons I have made of species from different formations have been unprejudiced.

I would add in conclusion, that it is highly desirable that a collection, as carefully made as that of Mr. Pratt, should be put in the hands of a skilful zoologist, who might carefully determine the species and give a complete list of them; and I would have undertaken this work myself if the stay of Mr. Pratt had been prolonged. I will only now say, that, besides a number of new species, I have found a considerable number also of which the analogues are met with at Chaumont, Parnes, Grignon, and the *calcaire grossier* of Paris; and it is worthy of remark that Mr. Pratt has found at Biarritz several new species of encrinites which remind one of those of the cretaceous period, and even of some found in the lias, as well by their large size, as by their external characters. It is to be hoped, notwithstanding the accuracy of Mr. Pratt's observations, that they may not be the last; and no doubt our colleague, M. Leymerie, will communicate to us before long the facts he has discovered with reference to this subject in the course of the present year.

D. T. A.

III. *On the GEOLOGICAL STRUCTURE of the Neighbourhood of BAYONNE.* By M. THORENT.

[As having reference to the above, I insert a notice of a paper read by M. Thorent before the French Geological Society on the same day as M. Deshayes' "Memoir," and referring to the geological evidence on the same subject. Some of the more important results however have been already given in a paper by Mr. Pratt, of which a notice appears in the "Proceedings of the Geological Society," vol. iii. p. 157. Ed.]

THE opinions of authors on the geology of the neighbourhood of Bayonne have been very various and discordant; some affirming that the sandy calcareous beds of Biarritz belonged to the cretaceous

formation, and others considering the lenticulite limestone of Bayonne as tertiary, without pronouncing on the Biaritz strata. It appears on first examining these localities that the limestones forming cliffs between *la Chambre d'Amour* and Bidart are contemporaneous, although a closer examination proves that there are two distinct series of different ages, so that the almost continuous bed which forms the cliff between *la Chambre d'Amour* to about 1000 yards beyond the rock of Goulet, are newer than those which next make their appearance, and from which they are separated by a gap in the cliff. At this place it would seem there has been considerable disturbance, the beds displaced being nowhere conformable to the limestones, like those of Bidart, however nearly they resemble them; but the nummulitic limestone observed on the road from St. Pierre to Briscons is conformable to another compact and crystalline limestone which is made up of fragments of corals. These limestones are not found in the cliff, and they ought perhaps to appear in the spot where the fracture has produced a gap.

The nummulitic limestones of the Biaritz lighthouse, and of the neighbourhood of Bayonne, have, however, no relation with those of Bidart, for they differ from them both in structure and composition, besides being unconformable. The cretaceous strata of Bidart and of the whole district west of the Pyrenees have a general uniform inclination, due to the elevation of the mountain chain; but after this other disturbances have taken place, accompanied by the protrusion of igneous rock. The cretaceous beds of Bidart, St. Jean de Luz, and of the whole western Pyrenees, thus offer clear marks of a general elevation succeeded by partial disturbances; and the dislocations are most considerable where the limestones are nearest the volcanic centre. The case is quite different with respect to the beds of Bayonne and Biaritz. These are conformable to one another, and they are very nearly horizontal, except in the recently disturbed districts.

It results from these geological observations that all the beds of coarse sandy and marly limestone of Bayonne and Biaritz, as far as the mill of Sopite, following the line of cliff, belong to a lower tertiary group; and that those occurring a little further on, as far as and beyond Bidart, are of the cretaceous period.

D. T. A.

IV. *On the STRATIFIED ROCKS of the LOMBARDIC ALPS.* By M. DE COLLEGNO.

[Read before the French Geological Society, Jan. 22. 1844.]

THIS memoir on the structure of the Lombardic Alps presents a minute detail of the geology of the district, and is accompanied by sections illustrating some of the more important points. The subject

is one of much interest as connected with the disturbances of the older and middle secondary period, and the elevation of the Alpine chain ; and, as M. de Collegno spent three summers in the country, and has been a careful and minute observer, an account of his paper will be of value to the English geologist, and more especially to the traveller crossing any of the principal passes of the Alps to visit the Italian lakes.

The sedimentary rocks appearing in the Lombardic Alps are of three geological periods ; viz. the Oolitic (including the Lias), the Cretaceous, and the newer Tertiary. On crossing the Simplon or the Splugen passes the stratified rocks may be seen near the axis of the Alpine chain, apparently conformable, and even alternating with crystalline rock ; and the fossils (Belemnites, &c.) found in the beds thus associated with gneiss, show the oolitic origin of the formation, although there can be little doubt that the modifications of the oolites attain their greatest extent in this part of the chain. To the north of the Lake of Como, saccharoid limestones dip away at an angle of 60° or 70° to the south, and repose on, or even pass into the gneiss, the limestone containing a quantity of mica at the junction. Towards the west the appearance changes, and the dolomite becomes fossiliferous ; but here also the rocks in immediate contact with those sometimes called primitive (granite, gneiss, &c.) are unquestionably of the oolitic period.

1. *Oolitic Rocks (including Lias).*

The oolites of the district we are considering may be subdivided into five groups, the lowest of which (1.) is a red sandstone, passing into a conglomerate, and sometimes into a breccia, of the same colour : its thickness is very variable, and it often contains quartz flints and fragments of gneiss and granite, but no mark of organic remains.

(2.) A black bituminous limestone, more or less schistose, and often so compact as to be used for marble, rests on the red conglomerate. It has been greatly disturbed and cracked since its deposition, and its thickness cannot be well ascertained, but it appears to be considerable. This bed is sometimes dolomitic, sometimes so bituminous as to give out a strong odour when struck, and sometimes so argillaceous as to become fissile, and even slaty. It contains fossils, the remains of fishes having been found in it, and even fragments of reptiles allied to *Plesiosaurus*. Univalve shells, resembling *Melania*, have also been met with in great abundance near Esino.

(3.) A greyish limestone overlies the black limestone, and is much more uniform in its character. It is remarkable for generally containing siliceous or cherty bands and thin beds of sandy marl. The colour of the limestone rarely varies, except on exposure, when it sometimes changes to a decided white. It does not seem to attain a greater thickness than about 200 yards, but it

extends along the whole district, and may be seen in the suburbs of Como dipping S. 20° E., and covered up with diluvium.

(4.) The bed next succeeding is a marly limestone of a brick-red colour, deposited in very even layers, four or five inches thick, and remarkably uniform in its colour and general appearance, more especially in the lower part. Notwithstanding this, the bed in question occasionally passes into a mere calcareous marl containing silex, which is, however, sometimes fossiliferous, and in this way is determined to be of the age of the inferior oolite. It is perfectly conformable to the underlying grey limestone, and passes by insensible gradations into the overlying bed, locally called *majolica*. This is strikingly seen on the road between Solzago and Ponzate.

(5.) The bed which forms the upper part of the oolitic series, as exhibited in the Lombardic Alps, has been distinguished by continental geologists by the Italian names *majolica*, *scaglia*, &c. It is a white compact limestone, exhibiting conchoidal fracture, and often full of large cavities partly filled up with crystalline carbonate of lime. This rock is often traversed by very narrow blackish-coloured veins, and is marked throughout its entire thickness by the occasional presence of silex. The brilliant whiteness of this limestone is such that it can usually be seen from a great distance; but it is sometimes coloured, and occasionally converted into dolomite. It has been often mistaken for chalk.

Of these beds, the red marly limestone (4.) contains in some places a number of remains of Ammonites; and the bed thus characterised is very easily recognised in the Italian Alps, being found at several points in the Apennines of Tuscany and in the Papal States; so that it appears to mark throughout Italy a geological horizon of which it is important to fix the exact date. M. Alc. d'Orbigny has recognised the following Ammonites from one locality in which this bed appears; and it will be seen from this list how low down in the oolitic series it must be placed:—*Ammonites heterophyllus*, Sow. *A. elegans*, Sow. *A. fibulatus*, Sow. *A. Walcoti*, Sow. *A. insignis*, Zieten. *A. radians*, Schlott. *A. scipionianus*, D'Orb. *A. thouarensis*, D'Orb.; and *A. comensis*, described by M. Von Buch, is from the same locality.

2. Cretaceous Rocks.

There are four subdivisions of the cretaceous system developed on the south of the Alps, some of them agreeing with beds probably contemporaneous in the south of France, and others almost peculiar to the district. They are thus arranged in order of superposition:

4. Variegated red and blue marls.
3. Nummulitic limestone.
2. Sandstone, more or less argillaceous, with numerous impressions of fucoids.
1. A conglomerate, sometimes used for millstones, and containing occasionally remains of Hippurites.

(1.) The conglomerate which forms the lowest member of the cretaceous formation is generally composed of greyish flints, and black or greyish fragments of limestone, and seems entirely derived from the degradation of the oolitic rocks. There are 80 or 100 yards of these conglomerates.

(2.) Immediately overlying the conglomerate is a fine grained sandstone containing mica, cemented by argillaceous and calcareous marls, the sandy beds being separated by thin marls. The whole thickness of the sandy group probably exceeds 100 yards, but the different beds are thin. The colour varies from bluish grey to yellowish, and rounded lumps of easily decomposing pyrites are found occasionally in it.

(3.) The Nummulite limestone is often compact, and its fracture sometimes conchoidal; but it more frequently contains marly fragments, and even becomes a breccia. Fossils abound in this limestone, but are not easily recognised, with the exception of the Nummulites, which are distinctly seen on the weathered surfaces. The thickness of the nummulite beds varies from half a yard to two or three yards, and the whole thickness of the series is about 80 yards.

(4.) The marls, which in Lombardy form the uppermost beds of the cretaceous series, are of a red or blue colour, and either very fissile and slaty, or more compact and solid, passing in the latter case into a red marly limestone, of which the mineralogical character resembles that of the red limestone of the oolitic series. The total thickness of these variegated marls is between fifty and sixty yards.

It is worthy of notice, with regard to the subdivisions of the cretaceous formation in Lombardy, that the Hippurite beds, and those containing fucoids, which in the south of France belong especially to the lower part of the series, are in Brianza intimately united with the nummulitic limestones, which in the maritime Alps are upper cretaceous rocks. It may hence be concluded, that the Monte Viso system of disturbances of M. E. de Beaumont has not extended to the meridian of Milan, so that the deposition has therefore been uninterrupted from the Hippurite to the Nummulite period; and M. Constant Prevot has already noticed this contemporaneity of Hippurites and Nummulites in Sicily. It is also to be remarked, that since the Nummulitic limestone of the southern Alps has suffered the dislocations of the Apennine system, there is this additional proof of the bed being of the true cretaceous period. The cretaceous beds above described exhibit amongst themselves no strongly marked separations, but seem to pass insensibly into one another.

3. *Tertiary Rocks.*

The only indications of marine tertiaries in Northern Lombardy consist of small patches of blue marl in the neighbourhood of Varesc. The best known of these is exhibited in horizontal

layers on the banks of the Olona, and contains numerous well-preserved sub-apennine species of fossil shells and large fragments of semi-carbonised wood. The fossils mark the pliocene origin of the strata. Besides these marine beds there is one of fresh-water origin, found on the banks of the Lake of Como and consisting chiefly of clay used in the manufacture of tiles and pottery, and others of the same date are found in the neighbourhood. Fossils are very rare throughout these strata.

The existence of small patches of tertiary marls in these localities is interesting, as marking points on the northern shores of the ancient pliocene sea, traces of which shores had been previously indicated by several geologists. They prove also that the general configuration of the Lake of Como was not much unlike what we now see, before the last disturbances took place, which have affected some of the lacustrine marls of Villa.

In conclusion, it is interesting to notice the general direction of the successive dislocations which have produced the actual *contour* of this district. These appear to be two in number, one of them having for its mean the direction of E.S.E., the general strike of the conglomerate and black limestones of the Val Sasina, of the dolomitic limestones of Menaggio, and of the cretaceous beds between the Lago Maggiore and the Adda. The other is exhibited in the oolitic formations west of the Lake of Como, and runs almost constantly E. 16° N.

D. T. A.

V. *A Description of certain BELEMNITES, preserved, with a great Proportion of their Soft Parts, in the Oxford Clay at Christian Malford, Wilts.* By RICHARD OWEN, Esq. F.R.S. &c.

[Read before the Royal Society, March 21. 1844.]

THE fossil shell called *Belemnite* has long exercised the ingenuity and research of the interpreters of ancient nature; and although sufficient evidence has, for some time, been obtained to determine both the ordinal and family affinities of the organisation of the animal constructing this singular compound shell, many additional and important facts have been arrived at by the examination of the well-preserved specimens from the Oxford clay, described in this paper.

In the compound shell of these specimens, the following parts are recognisable:—

1st. The terminal guard or sheath, resembling the head of a dart or javelin, whence the name *Belemnite* was first given to this part (which alone is generally well preserved), although it is now extended to the animal.

2d. The chambered or siphonated part of the shell called the

phragmocone, lodged in the conical cavity at the base of the guard.

3d. The conical, thin, but dense corneo-nacreous case, which immediately invests the phragmocone and lines the alveolus of the guard, commencing at the bottom or apex of that cavity, and continued beyond the last septum of the phragmocone to form the large anterior chamber of the Belemnite, containing the ink-bag and some other viscera.

The Belemnites have been classified according to the modifications of the sheath, and the species described is characterised by a rounded elongated conical guard, with a short terminal, ventral, longitudinal impression. It is called *B. Owenii* Pratt, and approximates in general form to *B. elongatus* and *B. longissimus* Miller, from the lias. The excavated part of the guard becomes very thin as it expands, and its thin and brittle margin may be traced nearly half way towards the base of the phragmocone, which is there invested only by the thinner and more yielding corneo-nacreous sheath. With respect to the guard, the most important additional information obtained by these specimens is an account of its microscopic structure. It consists of numerous thin, for the most part concentric, layers of minute prismatic trihedral fibres, placed at right angles, or nearly so, to the planes of the layers; the crystalline fibres are indicated by lines, which radiate from the central axis and cross the lines of growth; the lines which define the fibres run in pairs with a minutely and gently undulating course, resembling the tubes of dentine, but differing in the transparency of the intercepted calcareous matter, which is like that in the wider spaces separating the pairs of lines.

These differences in the intervals of the radiating fibres may depend on the different parts of the prismatic fibres, divided in preparing the sections made parallel to their course.

The exterior surface of the guard of the Belemnites is minutely granular, and occasionally presents faint traces of vascular impressions, proving it to have been invested by an organised membrane of the living Cephalopod; and in two specimens from the Oxford clay there have been detected remains of the more immediate investment of a thin friable layer of white calcareous matter, analogous to that of the outer layer of the sheath of the phragmocone. It is only necessary to add, with reference to the spathose calcareous constituent, that its microscopic structure proves it to be an original formation, deposited in membranous cellular moulds under the influence of the vital organising forces, and not the result of post-mortem infiltration of mineral substance into an originally light and porous or cellular texture.

As respects the phragmocone and its investing sheath, it is clear from the Oxford clay specimens, that the sheath is continued backward to line the alveolar cavity of the guard, as well as forward from its basal outlet to form the visceral chamber anterior to the phragmocone. The phragmocone appears broader than it actually was, on account of the compression which its frail walls were

unable to resist ; its basal part is usually squeezed flat, but sometimes one of the septa has slipped forwards so as to present its surfaces to the plane of pressure, and so retain its original form.

The septa are composed chiefly of nacre, with a thinner layer of white friable calcareous matter on both surfaces, which is seldom preserved. I have found twenty septa in an extent of two inches from the base of the phragmocone ; about an equal number of septa dividing chambers progressively diminishing in depth, and more rapidly in width, are indicated by detached phragmocones to have extended to the apex of the socket of the guard. The capsule of the phragmocone consists of a thin layer of mixed albuminous and opaque calcareous matter lined with nacre, but with a yellowish smooth outer surface.

The entire phragmocone, with its capsule, of these Belemnites from the Oxford clay, has been found not unfrequently isolated and detached, having slipped out of the alveolar cavity of the guard, and such specimens are squeezed flatter than those which have remained in, and been protected by, the guard. The yielding texture of the phragmoconic capsule has commonly caused it to fall into longitudinal folds when compressed after having become detached from the alveolus ; and if the change of form caused by compression were not borne in mind, the piles of concave plates would seem not to have been adapted to the alveolus.

It was long ago suggested (by Platt, in 1764,) that the shell of the Belemnite was due to the formative forces of the mantle of a molluscous animal, and the subsequent discovery of two grades of organization in the class of Cephalopoda* (the only mollusca to which it seemed possible to refer this fossil) called for a closer investigation, and led to the definite approximation of these with the other families of siphoniferous Cephalopods, now ranked under two distinct orders.

The first evidence that bore directly on the question of the position of the Belemnite in this class was the discovery of the fossil ink-bag preserved in the basal chamber of the phragmocone of one of these animals.

The importance of this discovery depended chiefly on the facts that the secreting gland and reservoir of the inky secretion common to all the naked Cephalopods do not exist in the recent *Nautilus pompilius*, and that no trace of them has ever been met with in connection with any of the simple or typical forms of fossil-chambered shells, as *Orthoceratites*, *Baculites*, *Ammonites*, &c. It appeared, on consideration, that the *Nautilus* might derive sufficient protection from its strong external shell, while, on the other hand, the active and highly organized naked Cephalopods might well require a compensatory endowment, enabling them to escape from danger. The presence of an ink-bladder therefore, since the branchial character of the naked Cephalopods is an essential con-

* Owen, "Memoir on the Pearly *Nautilus*."

dition of their muscular powers, would alone have implied an internal shell, the presence of muscular forces for rapid swimming, and the concomitant conditions of the respiratory, the vascular, and the nervous systems. The reference of the Belemnite to the Di-branchiate order, and the separation of their genus from *Nautilus* and *Ammonites*, was the conclusion arrived at by these considerations; and the specimen lately presented to the Hunterian museum by the Marquis of NORTHAMPTON exhibits a proof of the correctness of this view, since, besides the phragmocone, it shows the muscular mantle, a small part of the head, and a greater or less proportion of six of the cephalic tentacula, which are armed with horny hooks in a double alternate series, as in the *Onychoteuthis gigas*. It is evident also from this specimen, that in the proportion of the body, and in its elongated form, the Belemnite resembled the *Onychoteuthis* and most of the modern *Decapoda*.

Another specimen in the possession of Mr. Pratt exhibits, together with a portion of the muscular mantle and other parts, the ink-bag and duct, and the two fins. The reservoir of ink is situated two lines within the aperture of the phragmoconic capsule; it is of an oval form and jet-black colour; the inspissated ink is very hard, brittle, and splintering, but when reduced to a fine powder it presents a dark brown hue; and used as a pigment, works as smoothly as Roman Sepia, but with a deeper tint. The parts regarded as fins are flattened fibrous bodies, with well-defined semi-oval, external, and, apparently, free margins. The large end of the border is the anterior one, where the fin is broadest, and it gradually becomes narrow posteriorly.

It is interesting to find a rounded contour associated with an advanced position of the lateral fins in the ancient Belemnites, the rhomboidal form being most common in those fins placed at the end of the body; the only exception, indeed, to this being presented by the Loliopsis, which has terminal and rounded fins.

In Mr. Pratt's specimen, at the middle of the visceral mass, between the two lateral fins, there lies a compressed body of a horny texture and sub-bilobed form, on which may be clearly distinguished striæ passing outwards in opposite directions from a middle line, and diverging from each other in their course. It resembles the fibres of the digestive muscle in the gizzard of the Nautilus and other Cephalopods; and this apparent remnant of the stomach lies about half an inch in advance of the ink-bladder, in a position corresponding with that of the gastric organ in naked Cephalopods.

There is strong negative evidence that the Belemnite possessed horny mandibles like the other naked Cephalopods, since no calcareous beaks or Rhyncholites have been discovered associated with the specimens from the Oxford clay, or with those from the Lias.

The thickness of the layer of dried and compressed grey fibrous matter to which the mantle is reduced is half a line, and we may hence infer that in its soft and recent state, when permeated by its

sanguiferous vessels, it must have equalled in thickness that of a Calamary of the same size; and this indeed is evident, since the mantle of true Calamaries with horny pens (*Teuthidæ*) preserved in the same matrix is reduced to a compact fibrous layer of the same thinness.

The specimen now alluded to (Mr. Pratt's) is chiefly remarkable and valuable for the perfect conservation of the complex muscular structures of the head and its uncinated arms. Eight of these latter, forming the normal series of cephalic arms, may be defined, radiating from a contracted base. In this base may be observed two decussating groups of curved fibres; the posterior one, with its concavity turned towards the mantle; the anterior one, with its concavity directed forwards, and its horns continued into the bases of the arms. A similar decussated arrangement of fibres exists in the *Onychoteuthis*, and is described and figured by CUVIER in the corresponding part of the head of *Octopus*.

Almost the whole extent of five of the cephalic arms is preserved; they are rather longer, in comparison with the mantle, than in the modern *Onychoteuthis*, but not as compared with the entire body of the Belemnite, when this is lengthened out by the terminal guard: the longitudinal arrangement of the fasciculi of muscular fibres of the arms is very distinct.

Each of the arms seems to have been provided with from fifteen to twenty pairs of hooks, which were doubtless developed from the horny hoops which encircled the caruncles of the acetabula, as in the modern *Onychoteuthis*.

Two small protuberances at the origin of the normal brachia are the only parts which represent the bases of the pair of long tentacula superadded to the eight shorter arms of the existing *Decapoda*.

On each side of the head, behind the bases of the arms, there is a convex protuberance formed by a well-defined semicircular band, about a line in thickness, of grey fibrous matter, the fibres or layers being parallel with the curve of the band. In another specimen these parts are regularly placed in reference to each other, being on the same transverse line, with their concavities towards each other, and their convexities turned outwards: each body is a line in breadth, and does not diminish at either extremity, which is lost in, or hidden by, the surrounding muscular tissue; their structure is more minutely, but more definitively, fibrous than in the muscles, the fibres following the curve of the band. The parts in existing Cephalopods, which first suggest themselves for comparison with these, are the beak, the cartilage of the head, the cornea, or the crystalline lens. The position of the curved fibrous bodies is posterior to that in which the beak should be placed agreeably to existing analogies; the texture of the beak also in *Onychoteuthis* is the same as that of the hooks, whilst the texture of the parts in question is very different from the black horny matter of the preserved hooks. The position of the parts corresponds with that of large sessile eyes, only that they are more nearly approximated towards

each other. In reference to the large crystalline lens which characterises the eye in naked Cephalopods, the parts in question can only be compared, from their size, with the exterior laminæ of the outer division of the lens, in which case the larger and denser inner division of the lens has not at all been preserved; which is by no means a probable occurrence, and induces me to reject this analogy. If we compare them to the strong external tunic of the eye, their outward convexity would lead to their being referred to the cornea. But this part, in all existing Cephalopods, is a modification of the integument, and continuous with it, presenting a less degree of convexity than in the fossils, less thickness, and a less definite extent. Viewing, however, the relative position, form, and structure of the parts under consideration, the most probable conclusion respecting their nature appears to me to be that which refers them to the anterior or external tunic of the eye-ball, in which case they indicate a thicker, stronger, more distinct, more extensive, and more convex cornea in the Belemnite than in any known existing Cephalopods.

The evidence afforded by the above described specimens of the paucity in number, and superiority in size and complication, of the cephalic tentacles of the Belemnite, as compared with the Nautilus, yields another proof of the constancy of the laws of organic correlation; the very numerous, small, and comparatively simple tentacula of the Nautilus which illustrate the principle of vegetative or irrelative repetition, being associated with an essentially inferior type of Cephalopodal organization, into which an internal shell, a thick muscular mantle, pallial fins, and an ink-secreting apparatus do not enter.

In comparing the different forms of Cephalopods that have successively appeared and perished since the deposition of the Lias to the present time, we do not find that the highly complex organisation of the cephalic arms exhibited in the Onychoteuthis has been attained by or through progressive gradations, typified by the organisation of intermediate forms, for the ancient Belemnites manifested the uncinated armature as perfectly as the most formidable of the existing Onychoteuthides. Nor were true Calamaries with uncinated arms absent in those primæval seas which were tenanted by living Belemnites, Ammonites, and other extinct forms of Cephalopoda. The existence of naked Cephalopods of the family *Teuthidæ* in the oolitic secondary formations has been for some years demonstrated by the well-preserved and recognisable remains of the ink-bag, the gladius or horny pen, and the horny hooks developed from the acetabula of the cephalic arms.

In conclusion, if we compare the Belemnite as now restored, not conjecturally, but by observation of phenomena, with the known existing forms of the Dibranchiate or higher order of Cephalopods, in which its right of place can no longer be disputed, we shall first recognise in the outwardly concave plates and margino-ventral siphon of the chambered shell of the Spirula, the analogue of the hydrostatic part of the shell or phragmocone of the Belem-

nite : next, in reference to the entire shell we must admit that the *Sepia*, or common cuttle-fish, most nearly resembles the Belemnite in the general structure and position of its complex calcareous plate. The nucleus or terminal spine of the sepium or cuttle-bone corresponds with the terminal spathose guard of the Belemnite ; the convex posterior broad plate of horny with friable calcareous matter is analogous to the capsule of the phragmocone ; but its margins, instead of being approximated and soldered together, are free and lateral in position ; the congeries of transverse plates lodged in the concavity of the nucleus and of the foregoing semi-capsule of the cuttle-bone answer to the chambered phragmocone of the Belemnite ; but instead of being perforated by one or many siphons, they are entire, and connected with each other by a series of minute undulating lamellæ perpendicular to their plane.

The lateral fins of the *Sepia* are narrow, and extend, as is well known, from the apex of the mantle to near its base, while the fins of the Belemnite were relatively shorter and broader, and situated a little in advance of the middle of the body. In the relative size, shape, and position of the fins, the Belemnite must have most nearly resembled the species of the existing *Rossia* and *Sepiola* ; but it differed in the more elongated and slender body.

The character of the formidable hooks supported by the acetabula of the arms is now exclusively manifested by the genus *Onychoteuthis*.

Thus the extinct Belemnite combined characters at present divided amongst four distinct genera of Dibranchiate Cephalopods, — *Spirula*, *Sepia*, *Sepiola*, and *Onychoteuthis*.

But notwithstanding the uncinated character of the arms the balance of the natural affinities seems still to preponderate in favour of its position as a transitional link between *Spirula* and *Sepia* ; and the additional facts which we have now unexpectedly gained, while they show new and unsuspected radiations of affinity, tending to complete the reticular inter-dependencies of the Cephalopods, do not disturb, but confirm, the position of the Belemnite in the linear series of the genera of that class proposed in 1836.

The Belemnite, with the advantage of its dart-shaped and well-balanced shell, must have enjoyed the power of swimming backwards and forwards by the action of its cephalic and pallial fins with greater vigour and precision than the modern Decapod *Dibranchiata*. The position of the animal was most probably more habitually vertical than that of its recent congeners. Thus placed, the Belemnite, in quest of prey, would rise swiftly or stealthily to infix its claws in the belly of a supernatant fish, and then dart down and drag its prey to the bottom and devour it. And we cannot doubt but that, like the uncinated Calamaries of the present seas, the ancient Belemnites were in their day the most formidable and predaceous of Cephalopods.

D. T. A.

VI. *On the Form of GRANITIC ROCKS, and the Structure of GRANITE.* By L. VON BUCH, &c.

[Read before the Berlin Academy of Science, Dec. 15. 1842.]

[THE paper read by M. Von Buch on this occasion involves two subjects, namely, an expression of opinion and a record of observations concerning the structure of granitic masses, affording an explanation of the frequently described phenomenon of stratification in granite, and an account of a journey into Sweden, in which he pursued other investigations on the granite and gneiss of that country. The present notice is confined to the former subject.]

No object can be more striking than the beautiful bell-shaped form of the BROCKEN, as this noble mountain, towering above all that surround it, presents itself to the traveller who is approaching it from Elbingerode by way of Schierke. Nothing disturbs the perfect regularity of its parabolic surface, and a small house at the top, that would be undistinguishable on other mountains, is here a prominent object, standing out like a little wart from the surface. From other sides also, the same appearance is preserved, and the dome is so perfect, that during the ascent the actual summit cannot be seen until it is attained.

So completely is this dome-like shape preserved that, if the mountain were not accessible, it would be thought smooth and almost polished, and that therefore it could not be ascended. It is then with no little astonishment that we find, on actually reaching it, a wild and desolate waste rather than a smooth mirror surface. The whole is covered with innumerable blocks in such a manner that the spaces between them require constant attention from the climber lest he should fall into them, and these blocks are heaped upon another, especially near the foot of the mountain, without the slightest appearance of order.

This great covering with blocks is common to all ellipsoidal granite which, like the Brocken, has been lifted above the neighbouring formations. At Ramberg—a spur of the Brocken, they are so abundant and assume such fantastic forms as to be called “*The Devil's Mills*” in the ancient legends of the country. In other places, as the *Sturmhaube* in Silesia, in the Odenwald; and in the Schwarzwald, they are called seas of rocks (*Felsen-Meere*), and at Mount Parnassus they are known as *Daimonotona*, or “*Devil's Floors*.”

These two extremely general phenomena, the regularly circular form of granitic mountains, and the breaking up of the surface into millions of blocks, appear to depend on one another in some necessary relation. That the granite must be looked upon as a great bubble, even where most extended and far less beautifully exhibited than in the Brocken, is generally admitted by geologists ;

and it follows from this view that the granite thus lifted up from below cannot be considered as any kind of lava, or as a fluid substance filling up fissures from above, but that it possessed a certain consistency which in most cases was far removed from the condition of fluidity; and indeed the beautiful and regular external form which the rock assumes, renders any other assumption impossible. This degree of hardness or consistency, however, which the Plutonic rocks must generally have possessed at the time of their elevation into mountain-chains, does not exclude a certain degree of plasticity, a condition without which this kind of elevation can scarcely be conceived.

If, however, granitic masses are forced upwards in thick ellipsoidal bubbles by forces acting from beneath, it is also conceivable that such masses should neither appear in a fluid state nor break through the surface in detached fragments and needles, but present themselves in an arched or vaulted condition, the vault being larger and more perfect in proportion to the force acting and the extent of the surface acted on.

Now on examining the "sea of rocks" upon the Brocken somewhat more carefully, we shall observe a striking relation of the blocks amongst each other. They readily arrange themselves into a widely-extended cover of the granitic vault, and the separate blocks seem as if their projecting and re-entering angles might belong to one another. Unless, indeed, this were the case, one cannot imagine how the distant view of the Brocken could be so perfectly regular that a small house upon the top should be a conspicuous object. The blocks remain in their original position, for they certainly have not been brought here from a distance, nor can any decay of the surface have produced them, for a decay that could have effected this would have destroyed the marks of any relation which the blocks bear to one another; nor, lastly, can any violent disruption have acted, since such a disturbance must have altered the regular form of the mountain. The phenomenon is, I maintain, *the inevitable result of the contraction of the upper dome-shaped surface, and the circumstances under which it was pushed up from below*. If this is the case, we may understand how these seas of rocks may be common with regard to granite, and rare in other formations, since the granite, when it appears, offers a fresh surface; while other rocks, elevated by it, have had their surface long exposed.

If the existence of a similar contraction to this in the interior of granitic ellipsoids is admitted, an internal structure becomes unveiled, which demands great attention. That which we discover in the apparently disconnected blocks of the sea of rocks, a splitting up, namely, into conchoidal surfaces, exists also in the interior, and appears in a very singular manner. Large and compact concentric layers are seen, and the form of the circumference of the mountain is repeated by such concentric layers, gradually diminishing in size, until, at last, the innermost nucleus appears to be cylindrical, a singular arrangement, which may be seen in granitic bosses of

small circumference, but which, of course, cannot be followed in a large mountain, such as the Brocken. This remarkable concentric arrangement has often been mistaken for stratification; and this is not extraordinary, since we can generally see so little below the surface of the actual structure.

It is not, however, the case that every great granitic mass is a single ellipsoid in concentric layers. More frequently, and, indeed, generally, when the extent of the granite is considerable, several such systems run into one another, and smaller ones are included within the larger. Near the Brocken several surrounding hills exhibit each one its own vault-like dome, while all are united with the central ellipsoid of the Brocken itself; and in many other countries the same phenomenon may be observed, not only in northern Europe, but even in the southern part of India. In this latter country, Mr. Newbold informs us (*Asiatic Journal*, May, 1842), that the table land of Mysore exhibits similar spheroidal masses of granite, and observes, that the well-known experiments of Mr. Gregory Watt might have led us to expect such a result, as consequent upon the cooling of the rock after its elevation.

It thus appears that vaulted cavities, noticed in ellipsoidal granite, cannot be looked upon as the result of decay, but are, like the myriads of blocks described, the natural results consequent upon the elevation of the whole mass of the granite and the circumstances under which it was forced through the surface, like a bubble, from the interior of the earth.

D. T. A.

IV. NOTICES OF NEW BOOKS.

- I. DIE ORGANISATION DER TRILOBITEN *aus ihren lebenden verwandten entwickelt; nebst einer systematischen Uebersicht aller zeither beschriebenen Arten.* VON HERMANN BURMEISTER, &c. &c. Mit 6 Kupfertafeln. Berlin, 1843.*

THE European reputation of M. Burmeister, who is known as one of the most philosophical of all living Naturalists of the articulated tribes, would be sufficient to render any work prepared by him interesting and valuable, even if it related to a subject of less obscurity and difficulty than that he has now undertaken, namely, a description of the structure and analogies of the Trilobites. The probability that a complete English translation will soon appear†, renders unnecessary any very extended notice of this valuable work.

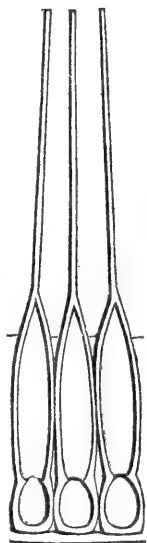
The introductory part of Dr. Burmeister's book is chiefly occupied with a history of the literature of Trilobites; and his researches, if one may judge by a list of upwards of a hundred memoirs on the subject, can hardly fail of being tolerably complete. His first chapter includes an account of the general external structure of the Trilobite, as deduced from the examination of the fossils. He considers, that since the remains of Trilobites are confined to the shell and casts of the shell, no soft part of the body either is or could be preserved, and that all the parts under the shell, or at least all those actually covered by it, are exhibited in the casts; while, on the other hand, those parts probably once existing, but which we miss in the casts, were not covered with a hard horny or shelly armour, and for that reason were not preserved. When, therefore, we find that the whole of the under part of the body, with whatever may have been attached, is absent in these fragments, it follows that these parts must have been soft and merely covered with skin, not by any means that they did not exist.

In the minute anatomical description of these singular crea-

* "The organisation of Trilobites, developed by means of their analogies with existing species, together with a systematic notice of all the species hitherto described;" with six copper plates.

† This translation will be one of the early volumes printed by the *Ray Society*, recently established (on the principle of the Camden, Parker, Sydenham, and other publishing societies) for the purpose of providing the subscribers with such valuable works on Natural History as are not likely to be undertaken by any publisher.

tures, the structure and form of the eye is naturally a subject of special notice, and the author combats the notion that two different types of structure are admitted in the eyes of different genera of Trilobites (*Calymene* and *Olenus*), expressing his opinion that all of them were provided with compound eyes covered with a smooth horny membrane, and that the appearance of facets in certain genera is only the consequence of the absence of this membrane. He also states that so long as eight years ago he had discovered the type of these eyes in a living species (*Branchipus stagnalis*), and that they were made up of four membranous coats of different kinds, the outer one being horny, smooth, homogeneous and transparent; and under this another existing of a different kind marked into facets and containing on a clear substance little, circular, equal-sized divisions, of a somewhat darker and harder material. The third coat of the eye consists of egg-shaped clear and very hard lenses, one of which is behind each of the window-like apertures just described. The fourth coat consists of an oblong crystalline body with a tuberculated surface, which with its upper thicker end embraces the pointed end of the egg-shaped lenses, and is covered by a thin circumscribing membrane. A continuation of this membrane envelopes also the lenses, and is attached to the thickened border of the little apertures before every lens. Behind the crystalline body comes a dark pigment, the chief mass of the whole eye, through which the nerves pass to go to the separate ocelli and touch the base of the crystalline body, so that their separation or forking encloses the before-mentioned separation of the crystalline substance and the lenses, and through these passes on in the same manner to the faceted membrane next in order.



It would appear that this description is perfectly applicable to those Trilobites having a smooth, horny membrane on the eye; and as in the living Articulata the number of the separate ocelli rather increases than diminishes as the whole eye is smaller, while the horny membrane is thinner as the eye is larger, we may understand that in these extinct genera the species with large, prominent, numerous faceted eyes may not in reality possess differently constituted organs of vision from those whose eyes are exceedingly flat and covered with a thick horny film.

In this short notice it is not possible to do more than allude to the greater number of Dr. Burmeister's researches on the different parts of the body of the Trilobite. He considers that the prominence in the middle anterior part of the horny helmet is the region of the mouth as it is in *Phyllopora*, and that all affinity to the Isopoda is thus widely departed from. He also alludes to the number of the rings or divisions of the horny shield as a matter of considerable importance in determining the position of these animals in classification.

In considering this latter important question—that of classification, there seems no doubt as to the fact that the Trilobites are Crustaceans, although whereabouts in that group they are to be placed is not so clear. Dr. Burmeister subdivides the Crustacea into two divisions—the *Malacostraca*, which are well known, and the *Ostracodermata*, these latter having compound eyes with simple horny membranes, all of them passing through various metamorphoses, and exhibiting more striking contrasts at different periods than the animals of the other division. These *Ostracodermata* consist of two groups, each comprising three families, the animals of the first group not having a distinct head with true antennæ and eyes, while those of the second are distinguished by the presence of very large and often enormous eyes and antennæ, which are most fully developed when the eyes are smaller. The two groups differ also in the nature of the metamorphosis which the species undergo. A table is given of the principal characters of these groups, and the author proceeds to consider to which of them the Trilobites are most nearly allied.

In the first place, he argues that they cannot belong to the *Malacostraca*, and that therefore all the apparent analogies with Isopoda at once cease to possess any value.* This conclusion he grounds upon the fact that they neither have true faceted eyes nor an ordinarily formed thorax, nor the constant number of from five to seven thoracic rings. The want also of large antennæ, of the broad shield-shaped head, and of visible articulated feet, and the unequal number of abdominal rings, all oppose such a view.

The resemblance of the Trilobites to *Limulus* is another analogy which Dr. Burmeister does not admit. The absence of detached head and thorax in this genus renders it impossible that there should be a close affinity; while the structure of the feet here also is dissimilar, these being perfectly well preserved in the *Limuli* of the Jura formation, so that they must have been covered with a hard or horny coat. For these and other reasons, the author considers *Limulus* to be still more widely removed from the ancient Trilobites than the Isopoda are.

Since then the Trilobites, from their analogies, seem to belong to the Ostracodermata rather than the Malacostraca, we have next to consider to which of the two principal groups of Ostracodermata they must be referred. The presence of large eyes sufficiently determines this question, and they fall therefore among the *Aspidostraca* or *Entomostraca*, with all the principal characters of which groups they are shown to agree (p. 40.). It appears, also, on more minute examination and comparison, that of the three families of this group, the Trilobites most nearly resemble the members of the *Phyllopoda*.

* The singular species *Serolis paradoxa* is referred by Burmeister to the Phyllopoda, the second family of the second division, as alluded to above. He denies the close affinity of this species to the Trilobites.

Having determined this, the author proceeds to trace the analogies between the Trilobites and the genera *Apus* and *Branchipus*, and others of the Phyllopoda, with a view of working out more accurately the affinities and the true place of the group. He concludes, that the Trilobites form a family nearly allied to the Phyllopoda, approaching this latter family most nearly in the genus *Branchipus*; and, therefore, forming a link between the *Phyllopoda* and the *Pacilopoda*.

The Trilobites having been articulated animals, must necessarily have cast their shell from time to time; and it has been already suggested by other naturalists that many fossils of this tribe, apparently new, are only the exuviae of known species. It becomes important, however, with reference to the habit of the animal, to determine what transformations it underwent, since all the Phyllopoda to which they seem so nearly allied undergo metamorphosis chiefly in the anterior part of the body. They leave the egg as unarticulated pyriform animalcules, and change considerably in appearance as they pass through their course of existence. It is the opinion of Dr. Burmeister, that a similar series of changes was undergone by the Trilobites, and that the so-called genera *Battus* and *Agnostus* represent only the shells of the young individuals of different species; and he explains at some length the reasons which have induced him to arrive at this conclusion. He also alludes to some other genera of the Palæozoic period presenting analogies with these singular Crustaceans; and concludes by stating, that we are perfectly justified, from the present state of the evidence, in forming an opinion concerning the habits of the animal. He states:—

1. That they moved by swimming, and inhabited deep water; but by no means crept on the ground at the bottom of the sea.

2. That in the natural position of swimming the belly was above and the back undermost; and that the power of rolling itself into a ball served the animal as defence against injury.

3. That its food was the smaller marine animalcules; or, in the absence of other prey, that it devoured the young of its own species.

4. That it probably did not inhabit the depths of the sea, but dwelt near the coast in shallows, and in innumerable multitudes; the individuals of one species herding together.

5. That in spite of the incredible multitude of individuals, the total number of species seems to have been small; and that in this respect Trilobites resemble the Phyllopoda, which, in spite of their individual abundance, belong to not more than a dozen species, although these are referred to as many as six genera.

6. The great difference in size observable in existing Phyllopoda renders probable a similar difference among the ancient Trilobites, so that very unusually large individuals do not necessarily require the introduction of a new specific name.

D. T. A.

II. GÉOLOGIE APPLIQUÉE, par M. AMÉDÉE BURAT, Professeur d'Exploitation des Mines à l'Ecole centrale des Arts et Manufactures, &c. 1 vol. 8vo. pp. 504. Paris.*

THIS treatise, by M. Burat, contains a large amount of useful information on subjects connected with mining, although it is chiefly valuable in reference to the mineral resources and the mining operations of France. The author introduces his subject by a statement of the relative importance of the various minerals in different countries, and states that, with regard to France, although in the eighteenth century there was a period of great activity, nothing was then undertaken with a view to the future, so that as soon as the stores existing near the surface were worked out, the competition with other countries threw a check upon these operations, and a large number, especially of the lead mines, were abandoned.

The first part of the "Géologie Appliquée" relates to the geological position of the useful minerals, and commences with a general view of the different geological formations. An arrangement is adopted, previously suggested by Werner, which groups all rocks that contain mineral produce into two classes, the first of which are characterized by being found stratified, or massive, while the latter occur only in veins, or are otherwise disseminated in comparatively small quantities.

This arrangement is convenient, especially in practical descriptions, as very distinct methods of working are adopted in the two cases.

It is unnecessary to dwell on the notices given concerning the sedimentary and igneous rocks; but a very useful chapter is written by M. Burat, defining the relative economic value of these and their usual mineral produce, and mentioning those parts of France in which they occur. A table is given also at p. 29. containing a statistical account of the results of quarry-work of all kinds, and the nature and value of the produce in the different departments of France, and to this are appended a number of notes, marking the limits of supply in the more important cases. The date of the table is probably 1840, and the total value of the supply is stated at somewhat more than forty millions of francs (1,600,000*l.*).

Continuing the description of the *gîtes généraux*, or instances of entire strata possessing economic value, M. Burat, having alluded to building-stones and other cases in which the rocks are quarried at the surface, proceeds to the subject of coal and other combustible minerals; and in this the application of Geology to economic purposes is ingeniously shown, and suggestions are given of great practical utility. Among these is one derived from the trials for

* This book appears without a date, an omission of some importance in a work which professes to give accurate statistical tables on subjects constantly changing. The editor obtained it in Paris in the autumn of 1843, and had reason to believe that it was then recently published.

coal at Mons, near Valenciennes, and thence to Douai, where, so long ago as in 1734, mines were opened, though unsuccessfully. The proprietors, in after years, followed the known direction of the axis of the basin in which the coal was lying; and although the cretaceous rocks covered up and hid the coal measures, yet as there appeared from the structure and condition of the associated old rocks that no great disturbance was to be feared, the search was pursued, and at length rewarded by the discovery of the mines of Anzin, after an expense of about three millions of francs (120,000*l.*) had been incurred. M. Burat then remarks:

‘Guided by the principle of the direction of the beds of coal and the strata containing them, as in this example, we may advance in our explorings of the carboniferous formation, if not with certainty, at least with a high degree of probability afforded by Geology; but in searching *à priori* for the carboniferous rocks, under the vast superficial area covered up by secondary and tertiary rocks which may happen to rest upon them, science can furnish no more than very indirect indications.’

The curious position of the coal in some of the Continental localities is next alluded to, and the structure of coal, the varieties of its appearance and inclination, and the occurrence of faults, are dwelt upon practically and usefully.

The origin of coal had already formed the subject of a Memoir by the author; and he here again alludes to the proof of its being due to the accumulation of large masses of decomposing vegetables, and that the leaves and stems preserved in the accompanying shales and sandstones are the only records remaining of the kind of vegetation at that early period.

The extraction of coal in France is greatly limited for want of ready and cheap communication; and this is so much the case, that five-eighths of the whole quantity extracted is obtained from four of the very numerous basins (not less than seventy) in different parts of the country. A large quantity of lignite and turf is annually obtained from different parts of France, and foreign coal is imported to a very considerable extent.

The supplies of rock-salt and of gypsum extracted from the earth are from very different geological formations in different countries. In England, as is well known, the beds of the New red sandstone contain rock-salt in great abundance; and so also do the variegated marls of cotemporaneous origin in the east of France. At Bex, in Switzerland, the same mineral occurs in the lias; in the Austrian Alps and the Carpathians it is found in the upper oolites and greensand; and in Poland in tertiary rocks; while in Catalonia and the Pyrenees it is sometimes in the cretaceous, and at others in the tertiary, beds that the salt-springs and salt occur. The presence of gypsum is almost invariably associated with the salt in some form or other; and coloured clays or marls are also so generally met with, that they seem to be almost necessary conditions for the presence of large masses of salt.

In the east of France the most common rock-salt is generally of a dirty-grey or blue colour, and when mixed with *salzthon* is occa-

sionally bituminous. The beds are numerous (amounting to 13 in number), and the total thickness is as much as 60 yards. The district of the Pyrenees, however, is more remarkable in this respect than Eastern France; and in the valley of Cardona there are two extensive and thick masses of rock-salt, united at their bases, one of which is worked as a quarry on the steep face of a hill. It is composed of eight beds, separated by red marls, and extends for about 130 yards by 250, with an unknown depth. The other is not worked. M. Burat, referring to the saliferous gypsum of Volterra in Tuscany, offers a few speculations with regard to the possible origin of these singular masses, and considers the latter to be connected with the *lagoni*, which are eruptions of aqueous vapour at a considerable temperature (105° to 120°), mixed with sulphuretted hydrogen gas. The singular beds of Seyssel and elsewhere, so remarkable for the quantity of bitumen they contain, are considered by M. Burat to be due to a similar agency.

The subject of iron ore bedded among stratified rocks next occupies our author's attention. Few of the French coal basins contain the carbonate of iron (the common ore of England) in any abundance, although small quantities, in nodules, are not rare. The basin of Aubin (Aveyron) is that which contains the most valuable seams of this mineral. Pisolitic ores of iron are common, and sometimes valuable, in some of the Oolitic beds of the Jura; and in several places they have been found worth working.

Having thus considered the various circumstances under which valuable mineral produce occurs in masses in stratified rocks, or actually embedded and alternating with the regular strata, the next subject introduced is that of the metallic ores contained in mineral veins. The meaning of the term vein, the nature of the cracks and fissures that contain ores, the particular appearances observable in, and the composition of, veins, occupy, as might be expected, a considerable space, and are very carefully and instructively shown. Nowhere, perhaps, is this difficult subject more simply explained and better illustrated than in these pages; and some beautiful engravings speak to the eye in a manner which cannot fail to be highly useful. A description of metalliferous districts next follows, from which it appears that in France there are four principal mining regions—that of Brittany, resembling the opposite coast of Cornwall, that of the Vosges, rich in argentiferous lead ore, the plateau of Central France, abounding in the same valuable mineral, and the chain of the Pyrenees, in which the ores of iron are of chief importance. Much valuable local and statistical information concerning these districts is given in the chapter now under consideration.

The mechanical contrivances made use of in actually obtaining the discovered ore, and reducing it to a state in which it is saleable to advantage, are next treated of, and occupy a considerable space; and a very detailed account is given of the contrivances by which the whole mineral produce may be best obtained with safety to

those employed, and without injury to the mine, or interference with subsequent operations. In this department the ventilation of mines is considered, and the safety lamps used in different districts described. Then follows an account of the mechanical preparation of ores, and the book concludes with a chapter on the general conditions of the working of mines. The remarks in this chapter are extremely pertinent, and well worthy of notice.

It appears, from the observations here made, that in France the proportion of miners killed or seriously injured annually in coal mines, has amounted to 1 in 144, while, in other mines, it is only on an average of 1 in 425. In the basin of S. Etienne, 698 miners have been killed or wounded in 15 years, and the general annual average of deaths in France, occasioned by mine accidents, is between 90 and 100, for an extraction of coal equal to that of Belgium, where the average is as much as 112.

The work of M. Burat is full of valuable information, and what is more, in a subject abounding so much with technical and statistical detail, is very readable. It is neatly illustrated, and contains a good index-geological map of France, marking all the carboniferous basins and the localities in which iron ore is found.

D. T. A.

III. THE MEDALS OF CREATION. By G. A. MANTELL, LL.D., F.R.S. 2 vols. pp. 1016. London, 1844.

THE object of the author in this work was three-fold, namely, first, to give an epitome of Palæontology; secondly, to assist the collector in his search for organic remains; and, thirdly, to place before the reader an exposition of the elementary principles of Palæontology. The book is illustrated with numerous wood-cuts, and several zincographic plates, some of which are coloured.

The first few chapters of the work are occupied with preliminary remarks, and an account of the arrangement and nomenclature of the British strata, the author including in his secondary series the Devonian system. He also considers the Cambrian series as distinct from the Lower Silurian, and omits noticing the presence of Silurian strata extensively developed in the Lake district of Cumberland and Westmoreland.

After these preliminary notices, the nature of fossils is explained, and many important hints given by which collectors of fossils may learn how to obtain and preserve specimens under difficult circumstances. To this succeeds a general account of vegetable remains, and a notice of the structure of coal, serving as an introduction to fossil botany.

In the chapter on this subject (Fossil Botany), the arrangement of Brongniart is chiefly followed, and most of the generic forms are illustrated by figures of characteristic species. With regard to the

interesting question of the relation between *Sigillaria* and *Stigmaria*, and the nature of the trees so called, several figures are given, and, amongst the rest, one in which roots, which are true *Stigmaria*, are seen attached to the trunk of a *Sigillaria* recently discovered (in 1843) near Liverpool, and the well-known paper of Mr. Brongniart, in the *Archives du Museum*, is quoted in support of the opinion previously entertained of the identity of the two genera. At the close of this chapter are some accounts of the occurrence of fossil flowers in the Monte Bolca tertiary limestone, and elsewhere, and fossil fruits and leaves of dicotyledonous trees in secondary and tertiary strata.

The second part of Dr. Mantell's work is devoted to the consideration of the fossil remains of animals, considered under different sections, namely, 1. INFUSORIA. 2. ZOOPHYTES. 3. ECHINODERMATA. 4. MOLLUSCA. 5. ARTICULATA. 6. FISHES. 7. REPTILES. 8. BIRDS. 9. MAMMALIA.

Under the first head are included the *Infusorial animalcules*, which have of late years been the object of careful examination by Ehrenberg and many English microscopists, and the *Foraminifera*, the species of the latter group found in the Cretaceous rocks, being those most recently brought under examination, are chiefly alluded to. Among the next group, the *Zoophytes*, the remains of sponges and spongiform bodies so universal in flint are described and illustrated, and an account is given of some of the more remarkable corals in each of the different geological formations.

The fossil remains of *Echinodermata* are described at considerable length, the various *Crinoideæ* being alluded to, and figures given of those parts most commonly found fossil. In alluding to the elegant little *Eugeniocrinite* or clove encrinite, the author has not adverted to the actual structure and probable appearance of the animal, a very good idea of which may be deduced from the specimens found abundantly in several of the continental oolites (of the middle period), exhibiting an appearance very different from that of the Lily Encrinite. Several extremely perfect specimens of fossil star-fish (*Goniaster*), from the chalk are figured in this part of the work.

The chapter on the Mollusca contains much information on this subject likely to be generally useful, and many excellent illustrations. In speaking, however, of the Hippurites, Dr. Mantell seems not to be aware that they occur in England, although fragments of them are not extremely uncommon in the lower beds of the upper part of the cretaceous series (Gault and Upper Greensand), and in the Cambridge Museum there is one specimen from the Gault, remarkably perfect and exceedingly instructive. The chapter concludes with a notice of the remains of the soft parts of mollusca, called by the author *Molluskite*.

The Cephalopoda are not considered with the other molluscan animals, but occupy a separate chapter. With regard to the Belemnite, Dr. Mantell has figured the suggested restoration of M. d'Orbigny, as well as that which subsequent observation has

confirmed, and which was proposed by Professor Owen. The Bellerophon is figured as allied to the Argonaut. It is worthy of remark that the *Aptychus*, well known in the Kimmeridge clay, and much more abundant in the somewhat newer Solnhofen beds of Germany, is spoken of under the name of *Pseudo-Ammonites*, and it is mentioned that the great desideratum is to find these fossils in natural connection with the shells or other parts of the Cephalopoda. It is, however, very frequently the case that they occur within the shell in the last chamber of Ammonites; and so many specimens exist in which this is the case, that we are naturally led to conclude that some relation between the two existed. The matter, however, is still doubtful.

The *Articulata* succeed the *Mollusca* in Dr. Mantell's arrangement, and amongst them the *Crustacea* are very fully described, the Trilobites occupying a large, but not an undue share of attention. The chapter concludes with a notice of the fossil insects and spiders that have from time to time been discovered in the various strata.

The notice of fossil fishes is naturally derived, for the most part, from the admirable researches of M. Agassiz, the latter pages of whose "*Recherches*," however, had not reached England at the time when Dr. Mantell's work was passing through the press. The chapter contains a short notice of such species (chiefly British), as exhibit most remarkably the peculiarities of structure of their class.

An account of the Reptiles—some of the most remarkable amongst which were collected under the author's own eye, and first described by himself—next follows; but it is professedly very brief, since the Reptiles, as well as the Mammals and Birds, have been the subjects of extended notice in Professor Owen's Reports, published in the volume of Reports of the Meetings of the British Association. The *Iguanodon* and the other Wealden species are chiefly dwelt upon, but a notice is given of each of the groups of fossil Reptiles in order.

In his account of birds, the author alludes to those of the chalk and Wealden district, and proposes the name *Palæornis*, to distinguish the species (allied, it would seem, to the Heron) found throughout the Wealden strata. He then gives a detailed account of the fossil footsteps of birds found in North America, and concludes with a notice of the New Zealand species *Dinornis*. A short notice of some of the more remarkable fossil quadrupeds concludes this portion of the work.

The third part of "the Medals" consists of notes of excursions, in illustration of the mode of investigating geological phenomena and of collecting organic remains, and it commences with some instructions to the young geologist before starting on such trips. The first excursion is abridged from a paper by Mr. Bowerbank, on the Isle of Sheppey, and the next is also by the same gentleman, and refers to Bracklesham Bay, a well-known locality for a peculiar fossiliferous sand belonging to the London clay, and

the chapter concludes with a few notes concerning the Isle of Wight.

The next chapter gives a geological account of the road from London to Brighton, and the structure of the Brighton Cliffs; we then have a few notes concerning the Great Western Railway and the neighbourhood of Bath, and next, a series of excursions in Derbyshire, commencing with a notice of that portion of the Birmingham and Midland Counties Railway between London and the station at Amber Gate, by way of Leicester. This latter trip is illustrated by a number of engravings and is given in some detail, and the chapter concludes with a short notice of the vicinity of Charnwood Forest.

A few names of dealers in fossils in several towns in England are added as useful to the collector, when hurriedly passing through a district interesting for its fossils.

This work is very neatly got up, and the illustrations, although unequal, are for the most part sufficient. Some of them are extremely beautiful in point of drawing and engraving.

D. T. A.

IV. GUIDE TO THE GEOLOGY OF SCOTLAND, *with a Geological Map and Plates.* By JAMES NICOL. 1 vol. pp. 272. Edinburgh, 1844.

THIS work is principally intended to exhibit in a systematic form the knowledge already attained and published on the subject of the Geology of Scotland. It is therefore entirely descriptive, and mentions in detail many phenomena chiefly of local interest. The author commences with an account of the Physical Geography of Scotland, and then states in very considerable detail and in regular order the Geology of the three districts of the country:—the southern district as marked by the rounded oblong hills with flat tabular summits composed of rocks for the most part altered and referable to the older Palæozoic period (for which the author retains the name transition); the central district containing the great carboniferous deposits; and the northern district consisting chiefly of gneiss, quartz rock, and clay slate, fringed along the line of coast by the Old red sandstone. To the accounts of these divisions is appended a notice of the Scottish Islands and a general summary of the whole subject; and the work concludes with a list of Scottish fossils, imperfect, no doubt, as the author acknowledges, but valuable as the first catalogue, and affording the means of correction and improvement.

By far the most important in an economical sense of the different formations developed in Scotland is the carboniferous series in the central district, occupying on the whole about 1750 square miles; but the most persistent and in some respects the most interesting bed is the Old red sandstone, of which there are nearly 5000 square miles. But the unusually large proportion of granite

and trap rock, and the enormous preponderance of the metamorphic rocks (occupying nearly 75 per cent. of the whole area of the country) give at once a distinctive geological character, and have principally influenced the general physical features of North Britain.

The speculations of the author concerning the Geological age of these extensive metamorphic rocks seem to point to the Silurian period as that during which they were deposited in a sedimentary slate; and since they underwent their great changes and probably became metamorphic before the Old red sandstone was accumulated in unconformable layers upon them, a more modern date is not at all probable. It is a remarkable fact, however, that while in Scotland large fragments of the more distinctly metamorphic rocks are frequently found, those of granite, gneiss, and mica slate are nowhere met with.

The Old red sandstone of Scotland has been the subject of special description by Mr. Hugh Miller, and the present work does not appear to add to our knowledge concerning it. The author indeed retains as Old Red the beds of Red sandstone containing footsteps at Corncockle Muir, respecting which Professor Sedgwick and Mr. Murchison arrived at the conclusion that it is New red; and he considers that the Old red passes into the red sandstones of the coal measures by imperceptible gradations. With regard to the latter series Mr. Nicol leans to the opinion of the coal having been formed in a shallow marshy lake, alternately submerged and lifted to receive the deposits of sand and clayey mud. The proportional superficial extent of the coal measures in Scotland is stated as amounting to one-seventeenth of the whole area (in the whole of Britain it is calculated at one-twentieth), and as being greater in actual extent than that of all the coalfields of France together.

The author offers a few observations concerning the alterations of level during the most recent geological period, the marks of which are evident in Scotland; and he alludes also to the earthquakes still occasionally felt. These latter are indeed more numerous than would be supposed, since Mr. Milne informs us that within the last century (from 1732 to 1839) not less than 139 have been noticed, although it would appear from the extreme irregularity of their direction and the difference they exhibit in the extent to which they reach, that they are in a great measure local, and depend therefore on partial causes. This is not always the case however, as appears from the fact that the great earthquake of Lisbon in 1755 was felt at Lochness, and that in 1839 a shock took place which was felt simultaneously over two thirds of Scotland.

This work by Mr. Nicol appears to contain a good summary of the main facts recorded concerning the Geology of his country, his principal object having been to describe the mineralogical peculiarities and the details of the structure of the older rocks.

D. T. A.

V. MISCELLANEA.

I. ORNITHICHNITES, *and the* COPROLITES *of* BIRDS.

SOME remarkably fine and perfect slabs, impressed with the foot-marks of birds, have lately been discovered in the sandstone of Turner's Falls, Massachusetts, by Dr. Deane; and are described in the number of Silliman's Journal for January, 1844. The finest of these impressions are upon shales with a smooth glossy surface, and one bed has been described containing more than a hundred foot-marks belonging to four or five varieties of birds, the entire surface being pitted by a shower of fossil rain-drops. The true characters of the foot of the ancient birds—the rows of joints, the claws, and the integuments—are all preserved in this interesting spot.

Of the various marks, the largest indicates a length of stride of about 12 inches; but the middle size, only one fourth as large, has a stride of 20 to 23 inches. It appears that the zigzag direction of the former indicates a heavy short-legged bird, while the other must have had long legs; it is also feebly impressed, and therefore probably belonged to a much lighter animal.

One of the slabs obtained is about 6 by 8 feet in dimensions, and contains upwards of seventy-five impressions; consisting of five sets and a half of the larger species, four sets of the smaller, and several others. They are all remarkably distinct. Another slab contains several of the larger steps, and a row of two impressions of an immense bird with a short broad foot, five inches by six, apparently palmated. The stride is twenty-nine inches, and the stratum seems to have bent beneath the great weight of the animal, impressing the bed next below.—*Silliman's Journal*, January, 1844.

In Silliman's Journal for Oct. will be found a paper by Professor Hitchcock on the subject of Ichnolithology, in the course of which he alludes to the recent discovery of the coprolites of birds in hard calcareous rock, associated with Ornithichnites. The spot in which they (the Coprolites) were found, seems to have been a resort of the bird, for numerous tracks here met with interfere with one another, and occur in successive layers. In the midst of them were found a few egg-shaped flattened bodies, about an inch in diameter and two inches long, of a dark colour, and considerably softer than the enclosing rock, which is very hard and compact. When broken crosswise, they usually exhibit a more or less perfect concentric arrangement, and are sometimes a little convoluted.

They adhere so strongly to the rock, that their precise external appearance has not been determined. In the inside of this mass small black grains may be seen resembling small seeds, the black matter of which is carbonaceous. When this is burnt off, the remainder of the fossil has been found on analysing it to consist of phosphate and carbonate of lime. It is supposed that the black grains are *seeds* which have passed undigested through the intestines, and have assumed in the passage such positions as these foreign bodies would and often do in the *fæces*.

A remarkable and beautiful result has been obtained by the application of the power of chemical analysis to these fragments. These are found to contain uric acid in the proportion of about one-half per cent., and from the circumstances under which it occurs it is concluded that the coprolite must have been dropped by a bird rather than any other animal. It also appears that the animal was in all probability omnivorous, a conclusion suggested by the analysis of the coprolite, and confirmed by the probable presence of seeds, as above alluded to.

II. *Memoranda of EARTHQUAKES IN UPPER ASSAM from January 1839 to September 1843.* By Capt. HANNAY, B. N. I.

[From the Journal of the Asiatic Society of Bengal, No. 58.]

1839. JANUARY 14th, 9 P. M. Shock of an earthquake felt at Suddeeah. Direction apparently from S. W. to N. E., preceded some days by rain and heavy snow in the mountains, air very cold.

June 3d, 8 P. M. At Suddeeah, apparently from S. to N., strong N. E. wind. Burrumpooter high, wet and disagreeable weather. Season unusually rainy from March up to this date. Small-pox prevalent.

1840. March 4th, 1 P. M. A total eclipse of the sun. When the sun was obscured the air was unusually cold and disagreeable to the feelings, even to nausea. About an hour after the eclipse (about 1 P. M.) a smart shock of an earthquake, and about ten minutes afterwards another; both shocks appeared to have come from the south. Sky cloudless, but atmosphere hazy.

1841. Feb. 9th or 11th. Felt at Gowhatty. This earthquake was different to those above mentioned; it was accompanied by a low rumbling noise; was sharp and stunning, as if a blow had been struck under the jaw; the others alluded to appeared, on the contrary, to have more of a trembling or rocking motion.

N.B. In February, 1841, at night, a splendid meteor was seen at Seesagur*, and in other stations in Upper Assam. It passed from

* Most of the shocks felt at Seesagur do not appear to be felt lower down the valley, but at Fezpoor earthquakes are said to be very frequent. There are no volcanoes in the neighbourhood, but the line of the Naga hills (nearer ranges) abound in iron and coal and numerous Petroleum springs, and in the Singpho country are springs of white mud.

east to west of the heavens, and burst with a loud report, the first like the firing of several large guns, and ending exactly like musketry file firing. Individuals on the frontier, who had not seen the meteor, imagined that some of the outposts had been attacked.

1842. January 4th, 7½ P. M. A smart shock felt at Seeksagur; the weather gloomy, cold, and threatening rain; cannot speak as to direction; shock similar in motion to those already noticed.

October 29th, 8 P. M. A smart shock, direction apparently from S. W. to N. E., trembling motion.

1843. April 6th, 8 P. M. After a very hot and close sultry evening, a severe shock of an earthquake at Dibrooghur lasted several minutes. The motion, however, was only trembling, affecting those houses which had posts built up by walls; direction appeared to be from W. or S. W.

1843. April 7th, Midnight. Slight shock felt at Dibrooghur. N. B. Both these earthquakes felt at Seeksagur, Jeypoor, and all over Upper Assam.

June 15th, 11 A. M. Smart shock; motion vertical.

17th, 8 P. M. A very smart shock; at first slight, and followed by a severer one; motion undulating, and, from the position of a clock which was stopped, must have come from S. W. or W.; lasted altogether about a minute. Weather rainy, with occasional light squalls from S. W. These shocks felt at Dibroo, Jeypoor, and Sakenah; that of this date at a few minutes past eight reported by the officer to have thrown down a portion of the bank of the Burrumpooter. An earthquake on this day at Ceylon.

September 3d, 2½ A. M. After as hot and sultry a day (the 2d) as I ever felt, the clouds gathered to S. W., indicating rain, but passed off without any; night very close and sultry; awoke by a smart shock of an earthquake; cannot speak as to duration.

7½ P. M. After a very hot day, clouds gathered at S. E., very close and sultry; squall came on a little before sun-set; vivid lightning all round the heavens previous to squall, making an extraordinary noise in the heavens over head, like the falling of heavy rain on distant jungle, or like the rushing of wind through a funnel; with this noise you heard an occasional growl like distant thunder.

When the rain fell, this noise, which had continued for some time, ceased; thunder very high in the heavens, but the lightning one blaze all round. While at dinner, smart shock from the S.

III. OSSEOUS CENTRES *of the* VERTEBRÆ *of* CARTILAGINOUS FISHES.

It is not generally known, although alluded to by M. Agassiz in the introduction to his great work on fossil fishes, that many if not all cartilaginous fishes (sharks, rays, &c.), have true bony nuclei

forming a solid frame-work actually capable of being preserved, so far as the union of one vertebra to another is concerned, after the removal of the whole external cartilaginous covering.

This being the case, the vertebræ of such fishes may be looked for in a fossil state, and there is as much probability of finding them as the teeth and bony spines which are generally supposed to be the only hard parts. This is the more important, since it appears that the teeth and bony spines alone afford no sufficient measure of the dimensions and proportions of the animal. Thus, from the size of the dorsal spine of a shark figured by M. Agassiz, it was concluded that the animal must have been of very large size, whereas it appears from the comparison of some vertebræ evidently belonging to the same individual, that it could not have exceeded two feet in length. Other instances of the same kind might be mentioned, so that the attention of collectors ought to be carefully directed to every appearance of vertebræ in localities where the remains of cartilaginous fishes occur, and specimens compared even when there would appear scarcely a possibility of the teeth and spines being referable to the same species as these rarer fossils.—See *Transactions of the Royal Society of Edinburgh*, vol. xv. p. 643. *et seq.*

THE
QUARTERLY JOURNAL
OF
THE GEOLOGICAL SOCIETY OF LONDON.

I. PROCEEDINGS
OF
THE GEOLOGICAL SOCIETY.

MARCH 6. 1844.

THE following communications were read :—

1. *On Two Fossil Species of CRESEIS (?) collected by Professor SEDGWICK.* By E. FORBES, Esq., F.R.S. F.L.S., Professor of Botany in King's College, London.

CRESEIS is a genus of *Pteropodous Mollusca* established by M. Sander Rang to include several species of simple, more or less acicular shells. Their surface is smooth or transversely striated, rounded, and sometimes presenting a longitudinal groove. The animal resembles that of *Hyalæa*, but is not furnished with the two caudiform lateral appendages with which the *Hyalæa* is provided. All the species are small, none being more than an inch in length. They are oceanic animals, free swimmers, and their remains are found in abundance in the fine mud of great depths.

Certain Palæozoic fossils, which have hitherto been confounded with *Orthoceras*, but which present no traces of chambers, and in other respects bear a close resemblance to the shells of *Pteropoda*, appear to belong to the genus *Creseis*, though gigantic in comparison with existing forms. Both the species now described and figured were obtained from the Denbighshire flag-stones.

1. *Creseis primæva*.

Very long, linear, dilated towards the oral extremity, smooth or with indistinct traces of longitudinal grooves.

Length of specimen (nearly entire)
8 inches.

Breadth at the aperture $\frac{10}{12}$ in.

Medium breadth $\frac{7}{21}$ in.

2. *Creseis Sedgwicki*.

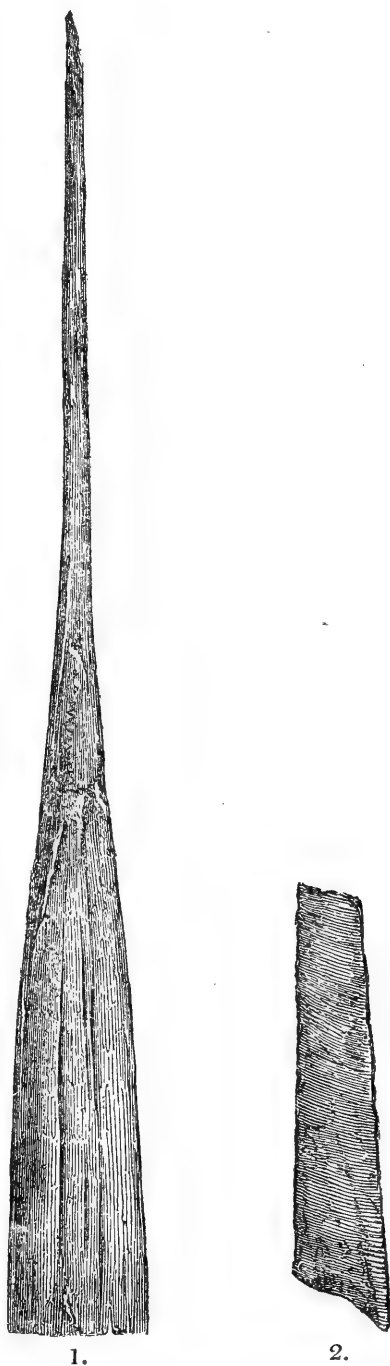
Shell cylindric, tapering, linear, marked with very numerous fine, regular, transverse striæ. Aperture dorsally angular.

Length of fragment $\frac{13}{12}$ in. [Probable length of specimen, $4\frac{1}{2}$ inches.]

Breadth at aperture $\frac{5}{12}$ in.

Medium breadth $\frac{7}{24}$ in.

Breadth at the aperture of another fragment $\frac{8}{12}$ in.



1. *Creseis primæva* E. Forbes.
2. *Creseis Sedgwicki* E. Forbes.

2. *On the GEOLOGY of NORTH WALES.* By DANIEL SHARPE, Esq., F.G.S.

[The notice of this memoir is postponed.]

MARCH 20. 1844.

William Pole, Esq., A.C.E., Professor of Engineering at Elphinstone College, Bombay, and Frederic Joseph Sloane, Esq., of Florence, were elected Fellows of this Society.

The following communications were read : —

1. *On FRACTURED BOULDERS found at AUCHMITHIE near ARBROATH.* By W. C. TREVELYAN, Esq., F.G.S.

IN a visit paid to the coast of Forfarshire in the summer of 1840, I observed, for the first time, at Auchmithie, near Arbroath, at the foot of a cliff consisting of old red conglomerate, some pebbles and boulders which had fallen from the rock above, and which, from their remarkable fractures and contortions, attracted my attention, and being in the same neighbourhood in the autumn of 1843, I found in the same spot many more specimens of the pebbles, some lying at the foot of the cliff and others remaining in their matrix.

Subsequently, in the picturesque conglomerate rocks at Dunottar Castle, near Stonehaven, I discovered similar appearances ; but, in this instance, the pebbles were much larger, and the fractured ones even more abundant than in Forfarshire.

At Auchmithie, the pebbles which predominate in the conglomerate consist of granite, porphyry, gneiss, jasper, and reddish quartz — those of the quartz being chiefly abundant. Of most of these different kinds of pebbles, fractured specimens may be found.

The conglomerate is traversed by veins of carbonate of lime and sulphate of barytes ; and it is in the neighbourhood, or in the actual course of these veins, that the fractured pebbles in many instances occur. Sometimes the parts of a pebble traversed by one of these fissures are faulted by it, and have their levels displaced to the distance of several inches. Thus it appears that the formation of the fissures and the fracturing of the pebbles have been contemporaneous.

It is to the bent appearance of some of these pebbles, and the appearance of their having been softened and the broken parts re-united as if by pressure, that I am desirous more especially to

direct attention. These fractures, contortions, and adhesions, appear to be the effect of violent mechanical action and of heat.

2. *On the Origin of the GYPSEOUS and SALIFEROUS MARLS of the NEW RED SANDSTONE.* By the Rev. D. WILLIAMS, M. A., F. G. S.

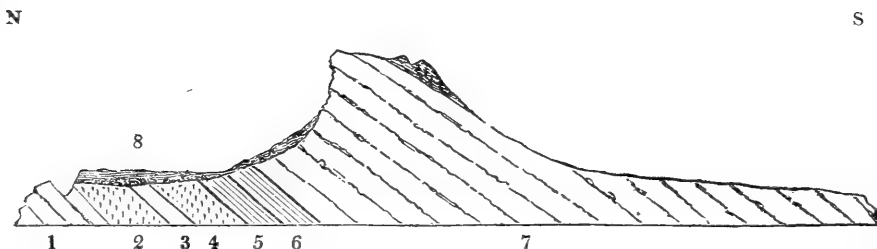
FOR years past I have had great difficulty in accounting for the marls of the new red sandstone, and as none of the explanations yet given appear to me sufficient, or satisfactorily account for the absence of molluscous and zoophytous remains in these beds, and still less for that of the numerous plants entombed above and below them, I propose in the following observations to attempt to explain these phenomena, in the hope, to use the words of Sir H. Delabèche, of arriving at the "knowledge of the true causes which have produced" the remarkable aggregates in question. In examining the district of Bleadon with a view to account for the phenomena of trap rocks presented in the railway cutting*, I observed in the superficial coating of soil on the northern flank of the hill above Weston-super-Mare, such abundant fragments of vesicular trap, some of them having the aspect of recent volcanic scoriæ, others containing spherical kernels of decomposing calcareous spar and hæmatitic iron, that I entertained no doubt whatever that I was standing on a dyke of ancient lava. The occurrence of these fragments for about seventy-five yards, in an east and west direction, indicated its strike, and rendered it probable that the same appearance would recur in the neighbouring coast cliffs. Those brown, strange-looking rocks, therefore, with whose aspect I had been long familiar, were volcanic aggregates, and were, in fact, two of the most interesting and instructive of the large number which had fallen under my notice.

These trap rocks are perfectly distinct from each other, and the nether one abuts so closely upon the road which forms the common approach to the coast below the cliffs, that no geologist passing could fail to see it,—indeed, could scarcely avoid touching it; though, like myself, every one had hitherto failed to remark upon it. In truth, the lower trap so intimately resembles a brown sandstone, and the upper one has so much the aspect of a mass of the ordinary red marl with imbedded pebbles, and, at the most accessible approach, is for the most part so truly a red marl, that the circumstance of its having hitherto escaped notice is not surprising.

Every bed in the series is, however, so unequivocally disclosed, and so readily accessible along the shore, that no doubt whatever can be entertained of their several positions. I propose to describe them briefly in ascending order, as seen in the subjoined section.

* See *antè*, p. 47.

SECTION through the Western Extremity of WORLE HILL.

Horizontal base, $\frac{1}{4}$ mile.

No. 1. is the ordinary grey mountain limestone, dipping S. S. W. at an angle of 35° .

Resting upon this, and dipping at the same angle and in the same direction, are the lower beds of No. 2., consisting of an indurated, red, fine-grained marl, which is succeeded by softer and more marly shales. The harder varieties contain the *Turbinolia* (*Cyathophyllum*) *fungitis*. Overlying these are beds which have the appearance of a dull brown sandstone; but which the eye, assisted by a magnifying lens, discovers to be a congeries of minute, red and brown, concretionary, oolitic granules, loosely cemented together by a green, filmy substance, imperfectly filling up the interstices. It acts like a file on the nail, but yields, when triturated, a fine red powder. It effervesces briskly with acids; and near the overlying bed No. 3., it contains shining facets of plates of a minute encrinite. This series, so far as I could measure it, is from 20 to 25 feet thick.

No. 3. lies conformably to No. 2., and commonly consists of a pale red, crystalline limestone, sometimes of a bright flesh colour, with small crinoidal plates and stems. Its upper surface is often grey and crystalline, and shows but little alteration from the trappean mass, No. 4., which rests immediately upon it. It dips S. S. W. 35° , towards its outcrop, but not so much below.

No. 4. is an amorphous mass of red trappean marl, about 30 feet thick, containing numerous globular, angular, and irregularly-shaped concretions, many of them standing in high relief out of it. They are of very varying forms and dimensions, from the size of a pullet's egg to four or more feet in diameter; and all of them attest their volcanic origin, more or less, by the greater or less abundance of air cells, now filled sometimes by spherical crystals of calcareous spar, and more rarely by red hæmatitic or steel grey iron ore. Sometimes these concretions are slightly vesicular, but at others they are more abundantly so than any trap rock I remember; and where the original air cells have been left void by the decomposition of the lime and iron, the matrix cannot be distinguished from a recent volcanic scoria. These lump-looking,

angular, and concentric spheroidal concretions, are distributed irregularly through the softer marly mass. They all have a variegated or red-marl-like basis, and pass insensibly from the most indurated and tough varieties into a friable red marl. The more typical marly variety is often of a globular, concretionary structure, and is composed of concentric layers, which are variegated red, buff, and pale green in colour, and are so friable that, under a slight blow of the hammer, they crumble into small cuboidal or polygonal fragments. The intermediate varieties are characterised by different degrees of induration. Most of them are rather tough than hard, and towards the western extremity of the trap have the aspect (but evidently not the mineral structure) of some of the Lizard serpentines; and throughout the exposed range of this ledge for about a hundred yards, both the hardest and most friable varieties are traversed by numerous veins of red and white fibrous gypsum, or of fibrous gypsum and calcareous spar.

The softer and more friable variety is best seen at the Dripping Well (a broad chasm in the neighbourhood), where it has been raised beyond the reach of the sea. It is there intersected by numerous fine lines of fibrous gypsum and calcareous spar. A little to the west the entire bed has been exposed to the action of the waves; but a prominent serrated ledge, in advance of the cliffs, marks the continuation of the harder and more crystalline variety further westward, for the distance of about a hundred yards.

No. 5., which rests conformably upon the last bed, is a pale red quartz rock, exactly like the red quartz rock of the Hotwells and Brandon Hill, near Bristol, which has been supposed to represent the millstone grit of the northern counties.

No. 6. is much the same as the last; but is more calcareous.

No. 7. is the ordinary grey mountain limestone. Some of its beds, on the shore, are parted by a red marly substance, similar to that of the trap rock, No. 4.

No. 8. is apparently a raised beach. It consists of sea sand, aggregated together into a tough compact mass by calcareous infiltration, and rests on an accumulation of stones so imperfectly rounded as to be neither a conglomerate nor a breccia. The sand itself has the character rather of the sea sand of Cornwall than of the sand of Uphill and of the other adjacent bays, containing, as it does, a considerable proportion of highly comminuted shells.

With regard to the trap rocks, there can be no doubt that they were ancient lavas, erupted, at two distant periods, over the floor of the sea, while the mountain limestone was in process of formation; the interval of duration between them being indicated by the interposed bed of limestone, No. 3., of which duration it is the measure. But where did the trap come from, and how was it generated? If I could not appeal to the case of the Bleadon cutting, as sufficient proof of its having originated in the fusion and conversion of mountain limestone and other underlying de-

posits, there is a natural section close at hand which might help us to the solution of the problem. The effects of exposure have here considerably effaced the evidences which the cutting through the rocks at Bleadon disclosed so admirably; but I found no difficulty in at once recognising them.

In the memoir already referred to, I mentioned that the cracks or joints and irregular hollows were filled with a variegated marly substance; and at Weston I noticed the face and joint walls of the limestone bed to be deeply eroded by many of the same deep cavities, in all kinds of positions; and, in several cases, the joint walls are even now red and discoloured. In two instances, one of an open joint, the other a cavity, they were filled by the same variegated red, buff, and grey laminated marls that I had met with at Bleadon. Several of the cavities show, internally and on their edges, a strikingly rough and irregular outline. They are all of them many feet above the highest spring-tide level, and are often so overhanging or highly inclined that stones could by no possibility be contained in them; and the other limestone beds exposed along the coast exhibit nothing of the kind. The lower portion of the bed is hidden by an artificial platform of stones; but evidences enough remain, within the space of a few feet, to indicate the circumstances under which these trappean marl rocks were generated, and of the date when they were erupted. A north and south fissure, which has riven asunder the beds marked 2, 3, and 4. on the section, and which is partly filled at the bottom with a hard red marl, was probably the vomitory through which the upper trap was ejected.

Two instances of trap rocks, of the same mineral composition, one generated *in situ*, the other erupted, with the effects produced by both on the immediately adjacent rocks, are rarely perhaps to be met with so well disclosed and in so short a distance as in the case between the Bleadon cutting and the cliffs of Weston.

In using the terms fusion and conversion, I wish it to be distinctly understood that I never supposed that any one elementary earth or substance could be converted into another: such as that lime, for example, could become siliceous. I contend, only, that the limestone has been converted into trap, volcanic mud, or marl, as the case may be; and I entertain little doubt that a chemical analysis of these would show that the mineral constituents of the former existed in the latter; though, no doubt, in different, and, perhaps, very varying proportions.

I will conclude with one more remark on the immediate subject of this communication. The association of variegated marls, salt, gypsum, and magnesian limestone in various places at different geological levels appears assignable to some one cause which has been common to all. When, therefore, we mark the close analogy, the identity in many respects, of these peculiar aggregates with a variegated, gypseous and apparently magnesian marl, which is incontrovertibly a volcanic product, we may be supposed to have ascertained the common origin of both; and instead of multiplying

causes, we ought rather to class them among the formations which owe their origin to volcanic action.

These gypseous marls, more or less adjacent to, and (as I consider) derived chiefly from the elevated and dislocated mountain limestone, are, in many respects, analogous to the crystalline and clay slates among the more disturbed grauwacke and other districts; and I entertain no doubt that other rocks referable to the same origin will be found accompanying such dislocated strata as are traversed by igneous rocks, to a greater or less amount, whatever the age of the strata may be.

April 3. 1844.

John Wilson, Esq., of St. John's Wood; Andrew C. Ramsay, Esq., of the Ordnance Geological Survey; and Charles Pope, Esq., of Temple Cloud, Somerset, were elected Fellows of this Society.

The following communications were read:—

1. *On the Occurrence of Fossils in the BOULDER CLAY.* By ROBERT HARKNESS, Esq., of Ormskirk.

THERE can be no doubt that the presence or absence of fossils in different formations is owing to other causes than the actual existence of animals and vegetables on the spot and at the time of deposition, and is, indeed, generally the result of local circumstances; but the "boulder clay," the formation of which the author of the present paper endeavours to explain the cause, presents similar characters in districts widely distant, and is also remarkable for the paucity of its organic remains.

The deposit in question belongs to the geological period immediately antecedent to the existing epoch, and consists of clay containing boulders of various kinds of rock, scattered without order through its whole mass. It occurs on various parts of the coast both of Great Britain and Ireland, but appears to be most fully developed in the basin of the Clyde, where it overlies a series of beds of fine clay containing numerous remains of shells. Similar remains have been found in many elevated sea beaches; and it has been concluded from the examination of them by competent naturalists, that the climate must have been more arctic at the time of their deposition than it is now in the places where they are found.

The author of this communication, referring to the known increase of temperature of the earth at increasing depths, and the law of change of temperature in the ocean at certain depths, thinks it possible that, although the land was exposed to intense cold, the sea might yet have contained certain animals requiring greater warmth which may have lived at considerable distance from the surface;

and he thinks it probable, for this and other reasons, that the deposit of the boulder clay was formed in a deep sea.

2. *On the Traces of the Action of GLACIERS at PORTH-TREIDDYN, in CARNARVONSHIRE.* By ROBERT W. BYRES, Esq.



MAP of the supposed Path of the GLACIERS from SNOWDON.

- | | |
|------------------------|--------------------|
| a. Moel Hebog. | f. Tremadoc. |
| b. Moel Wyn. | g. Portmadoc. |
| c. Bedd Gelert. | h, h. Traeth Mawr. |
| d. Pont Aber-glas-lyn. | i. Traeth Bach. |
| e. Brynteg. | |

The following notice, bearing date the 16th of October, 1841, appeared in the Visitors' book at the Goat-Hotel, Beddgelert:—
 "Notice to Geologists.—At Pont-aber-glas-lyn, 100 yards below the bridge, on the right bank of the river, and 20 feet above the road, see a good example of the furrows, flutings, and striæ on rounded and polished surfaces of the rock, which Agassiz refers to the action of glaciers. See many similar effects on the left, or south-west, side of the pass of Llanberris. WILLIAM BUCKLAND."

This notice led me to search for the same effects in other places in the same neighbourhood, and I found similar traces on many of the rocks between Aber-glas-lyn bridge and Tremadoc. In February last curiosity led me into the Flag-quarry, which lies about 300 yards from the mail-coach road, at Porth-Treiddyn; and for the purpose of examining the joints and split of the rock, I

ascended from the quarry to the top, where a space of ground had been cleared of the soil and detritus, preparatory to further quarrying. Here I was much struck by the polish and undulations of the surface of the rock; and a detail of my examination of these phenomena will leave no doubt, I think, that they are attributable to the action of glaciers.

The slope of the mountain at Porth-Treiddyn is to the north and north-east; and the dip of the rocks is in the same direction, at an inclination of from 17° to 22° , but the angle increases as you ascend.

At the spot which had been cleared, above the quarry, the detritus lying on the surface of the rock was from five to twelve feet thick. It consisted of various soils and gravel, of blocks of rock similar to the flags, and of boulders of porphyry and greenstone, in some of which the felspar crystals were very distinct. Some of these boulders were from three to four feet long, and from two to three feet in diameter.*

It is here, especially, that we have presented to us a perfect type of the glacier action. The surface of the uncovered portion of the rock, when it has not been disturbed by the workmen's tools, is rounded and polished in the most extraordinary manner. The surface is furrowed; and the furrows, where the rock is uneven, are from 1 to 2 feet deep, with their edges beautifully rounded off. On the broader slopes, striæ are very distinct. With a few exceptions, which I shall presently take occasion to notice, the furrows, striæ, scoops, grooves, and undulations, all shape their course, not in the direction which water would take, that is to say, in the direction in which the mountain slopes, northwards; but in a diagonal or slanting direction, towards the valley of the Glasllyn, that is to say, towards the east or north-east.

There are a few channels, from 1 to 2 feet deep, which run in a north-westerly direction; these channels appear to have arisen from the form of the rock compelling the superincumbent glacier, with its included blocks, to move that way, until the obstacle was overcome, when the moving mass resumed its original course.

With this example of glacier action for our guide, other places where, from lapse of time combined with other causes, the traces of that action have become somewhat obscure, and might consequently appear doubtful, will be regarded as affording clear evidence that there also the same cause has been in operation.

The same phenomena are traceable from Porth-Treiddyn higher up the mountain, to the very top, which is rather more than half a mile from the spot where these effects are first visible. In cutting the new road to the quarry, many rocks have been exposed, which show, by their polished faces, that the whole side of the mountain has been acted on.

* On the southern side of this mountain, and very much below the level of the quarry, may be seen broken and but seldom rounded masses of these rocks, in which felspar, hornblende, and shorl are disseminated.

Where light and air have acted, much of the delicacy of the cutting has been obliterated; besides which the surface is covered, in part, with heath and lichens. Notwithstanding these disadvantages, the most beautiful example of the power of a loaded mass, when making its way in a slanting direction, is to be seen on the high road, at the commencement of the new road to the quarry, exactly within the gate-posts. In this place, the more delicate striæ are visible, with the flutings and furrows; and these are cut in such a manner as to show that the pressure was downwards, the action slow, and the motion irregular; and in places where I have removed the moss and heath, the surface has a tolerable polish, readily perceived by any one who has seen the upper quarry. In this spot occurs an example in proof of slow action, in the work of grooving the rock. Two semicircular grooves, about an inch deep, and about a foot apart, proceed parallel to one another for some distance, when they gradually curve round and then meet, and one of the grooves proceeds onwards from the centre downwards. The form of the grooves may be represented by the letter Y. Here, as in other places, it is evident that the cutting substance changed its position, and for a time remained stationary, though still continuing its grinding action, since a cup or cell has been formed to a greater depth than the fluting above or below.

With so perfect a type as that of Porth-Treiddyn, of what Agassiz refers to glacier action, I have been enabled to trace that action at various other points in Carnarvonshire between Tremadoc and Aber-glas-llyn bridge, and also on the other side of the Glas-llyn river in Merionethshire; but the furrows and other striking peculiarities are not so evident in these other localities as they are at Porth-Treiddyn.

In the space represented in the drawing, glacier action may be observed, —

1st, at the town rock, immediately above the village of Tremadoc :

2dly, at the farm-yard :

3dly, at Porth-Treiddyn, already noticed :

4thly, at a point by the road side, where there occurs a perfect sample of polished rock. This lies a little beyond the rock-crystal quarry, where tabular crystals of titanite, called brookite (if I remember rightly) were procured.

5thly, at a point near Brynteg.

Beyond Brynteg, towards Aber-glas-llyn bridge, many other examples of glacier action may be seen, which are those referred to by Dr. Buckland.

In the foregoing remarks, I have confined myself to an extent of 6 or 7 miles; but I know that there are other cases, which at some future day I may explore; and I will now conclude by saying that I have attempted to describe one of the greatest curiosities in the country, which will amply reward, by its inspection, all lovers of geology.

3. *On the Existence of FLUORIC ACID in recent BONES.* By G. OWEN REES, Esq., M.D.

THE author in this communication wished to direct the attention of geologists to the experiments connected with the presence of fluoric acid in bones that have undergone no change consequent upon fossilisation. He states that in the experiments he made, the bones were tested both before and after calcination, but that there was nowhere the slightest indication of fluoric acid in recent human bones, although immediate evidence of its presence was obtained when fossil ivory was submitted to examination.

The analyses of fossil bones have, according to Dr. Rees' statement, shown the existence of a very large proportion of fluoride, in some cases as much as 10 or 15 per cent., which is an enormous increase on the largest proportion ever declared to exist in recent specimens. He argues, therefore, that since so much of the fluoride of calcium is introduced in fossilisation, the whole may have been.

He concludes by alluding to the unsatisfactory state of the question at issue, namely, whether the bone and ivory while undergoing the process of fossilisation have their phosphoric acid transmuted, or whether a fluoride exists undetected in the soft parts of animals, which during their decay decomposes the earthy salts of the bones.

APRIL 17. 1844.

H. B. Mackeson, Esq., of Hythe, and Sir Thomas Edward Colebrooke, Bart., of Colebrooke Park, were elected Fellows of this Society.

The following communications were read :—

1. *Observations on the GEOLOGY of the Southern Part of the GULF OF SMYRNA and the Promontory of KARABOURNOU.* By LIEUT. T. SPRATT, R.N.

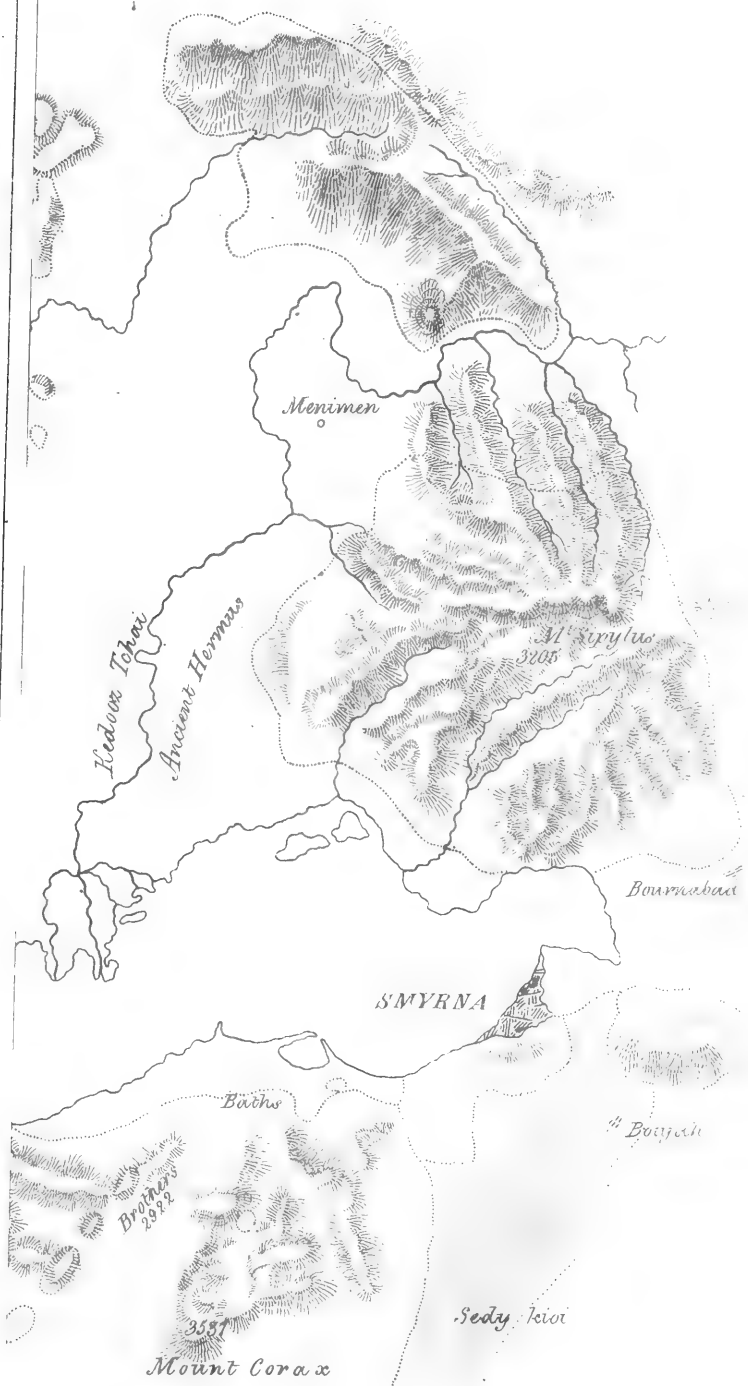
THE observations contained in this paper continue the subject from the point at which it was left by Messrs. Strickland and Hamilton in their memoir on the geology of the neighbourhood of Smyrna*, and relate to the western boundary of the lacustrine deposits which lie to the south of the town of Smyrna, forming and in part surrounding the plain of Sedi-kieui; so called from a village of that name situated on its western margin.

Immediately over the village there rises a series of ridges, flanking a high mountain that forms one of the principal features in the arm of land which separates the two gulfs of Smyrna and

* Geol. Trans. 2d ser. vol. v. p. 393.

0 5 10

10 English Miles 69.1 = One Degree.



Printed by Reeve Brothers

GEOLOGICAL MAP

of
the Country bordering the
Gulf of Smyrna:

by
Lieu^t Spratt R.N., F.L.S.

Lacustrine
Marls &c.

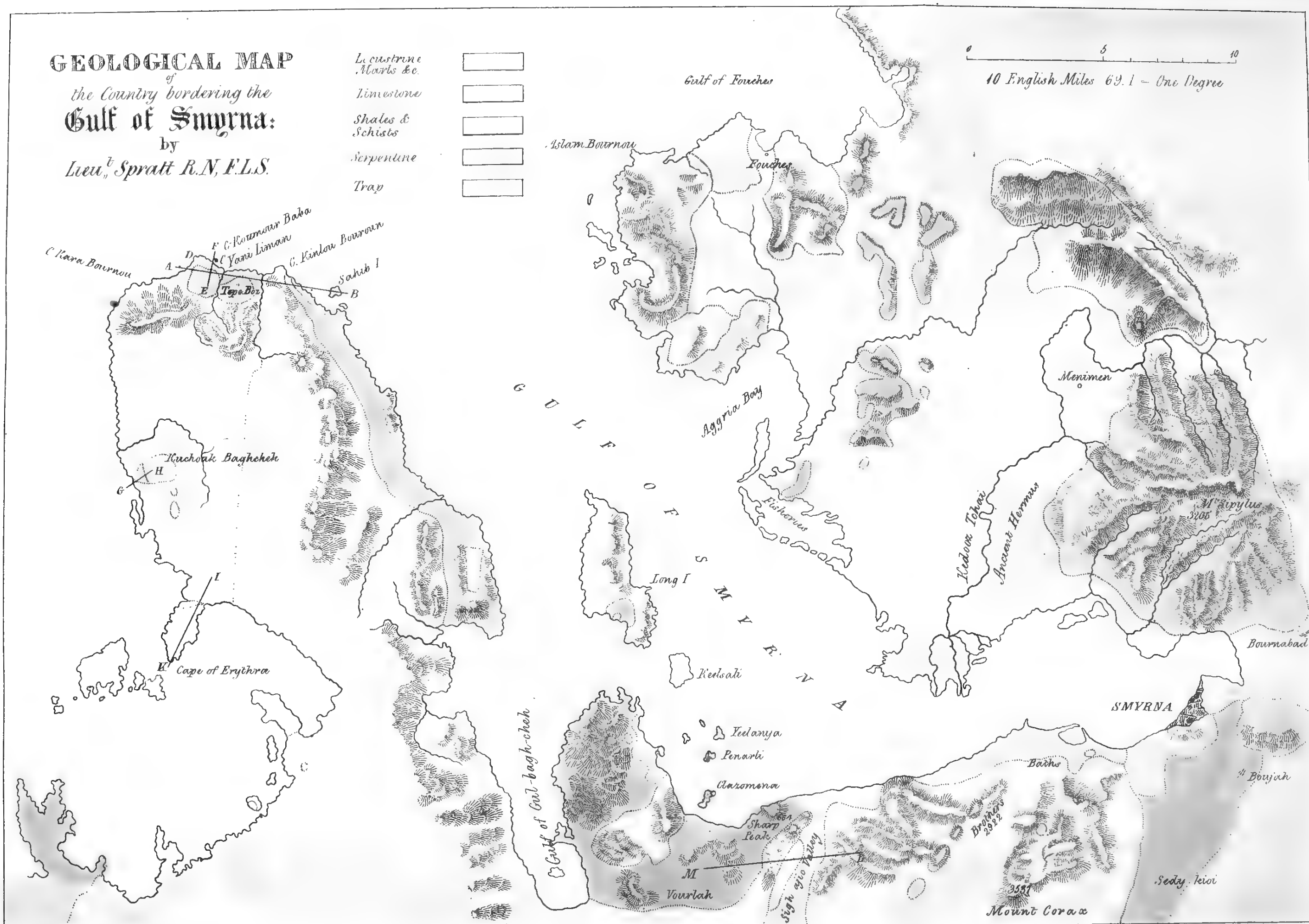
Limestone

Shales &
Schists

Serpentine

Trap

0 5 10
10 English Miles 69.1 - One Degree





Ephesus. This mountain was the CORAX of the ancients, and attains a height of nearly 4000 feet, stretching from shore to shore on both sides of the peninsula.

The north face of this mountain is channelled by deep ravines, and the intervening ridges attain a very considerable elevation, almost to their terminations; so that the whole mass rises abruptly out of the plains and from the shore at its base.

In lithological structure these ridges consist of dark-coloured shales and schists, which dip at high angles (from 30 to 50 degrees) round the central and most elevated part of the mountain, but the rocks which compose this central nucleus I had no opportunity of observing.

At the mouth of one of the deep valleys, descending from the summit of the mountain, is a hot bath, the position of which is marked on the map.* Besides the spring which supplies this bath, several hot jets of water rise through the sand in the bed of the torrent in the ravine, in one of which the thermometer stood at 150° Fahr.; and very lately in an attempt to sink a well through the alluvium of the adjoining plain at the base of the mountain, springs of hot water were met with at about 10 feet below the surface, so that there appears to be a considerable supply of heated water which deposits some mineral (apparently sulphur), and escapes by a subterranean course.

As the schists and shales appeared to be best developed in the sides of the deep valley which opens behind the hot springs, I ascended it for about four miles. Its sides were steep and precipitous, and I observed that the rocks consisted of a series of brown and greenish shales and schists, interstratified with quartzose grit and a hard sandstone, composed of particles of quartz and mica. Sometimes compact siliceous strata occur; and not unfrequently beds and nodular masses of jasper, as well as crystalline limestone. At the mouth of the ravine the dip was 35°; about a mile above increased to 50°, and two miles further, in contact with some igneous protrusions, the schists, &c., are nearly vertical. The volcanic productions in this neighbourhood appear to be of three kinds, and occur near each other, within the space of 200 or 300 yards, in the form of dykes, from 10 to 20 feet broad. In contact with the igneous rocks the shales were much more indurated than usual, and of a redder appearance on the exposed surfaces. Beyond the dykes the beds assume their former dip of 50° to the N.N.W.

These shaly and schistose deposits must be of very considerable thickness; at least a thousand yards of them being exposed between the mouth of the valley and the point to which I ascended; and, from what I was able to judge, they appeared to extend as far again, but I could nowhere discover a single trace of organic remains.

The next part I examined was a ridge about three miles to the

* See the map accompanying this memoir.

west of the Hot Bath Valley, on the summit of which stand two remarkable peaks, known by the name of the Two Brothers. These peaks, although separated only by a few hundred yards, consist of detached masses of a grey semi-crystalline limestone, of about 300 feet in thickness. A chain of calcareous matter, of variable thickness, may be traced through the whole mountain to the south-west, following the line of stratification; and being more durable than the associated shales, the harder rocks stand up in isolated points above the wasted strata in which they are embedded, and with which the stratification of the limestone is always conformable.

They are, however, split and shattered by numerous transverse fissures, which at a short distance appear like lines of stratification. In the shales which underlie these rocks occur calcareous laminæ as well as calcareous nodules, varying in size from that of a nut to that of an orange. The shales are here very friable, and of a pale chocolate or cream colour, like those at the foot of Mount Pagus, near the Caravan Bridge (mentioned in the memoir of Messrs. Strickland and Hamilton), and they contain crystals of a mineral which appears to be garnet. These shales are 300 or 400 feet in thickness, and below them others which are indurated are found in the valley above the hot baths.

At the western base of Mount Corax is a low isthmus crossing between the gulf of Smyrna and the bay of Sighajik, which separates the mountain from the district of Vourla. The greater part of the isthmus is an alluvium of gravel, covering the schist and shales; but on the opposite side of the isthmus these latter rocks reappear, dipping at the same angle as in the foot of Mount Corax (45° to W.N.W.), passing into a ridge of limestone, semi-crystalline, and greatly resembling the limestone of the Two Brothers; the crystalline condition, however, being in neither case due to any immediate contact with volcanic eruptions. The limestone now continues throughout the promontory in peaks and ridges, whose height varies from 1000 to nearly 4000 feet. Near the shore, on the west side of the isthmus, rises one of these peaks, which is sharp and conical, and crowned by an ancient fortress. On its western base repose, in a horizontal position, compact white calcareous strata and greenish marls, identical with the fresh-water deposits described by Messrs. Hamilton and Strickland as existing in the vicinity of Smyrna. These deposits occupy a considerable district round the modern town of Vourla, as well as in other parts of the Promontory of Karabournou and the islands within the gulf, and they are indicated in the map by the yellow colouring. Of the lacustrine origin of this formation there is the fullest evidence, from the number and variety of fresh-water shells which are found imbedded in the different strata, and in the probably contemporaneous fresh-water basins of the interior of Asia Minor. In some localities the fossils are very abundant, as on the road to Vourla, about two miles to the east of the town, and in the small islands which form the anchorage of Vourla.

SECTION from the VOURLA BASIN to the foot of MOUNT CORAX.*



The lacustrine deposits surrounding Vourla extend to the head of the Gulf of Gul-baghtchek on the west, but the promontory jutting out towards the Vourla Islands is divided across by a hill of brown trachyte, which separates the fresh-water formations at the extremity of the promontory from those in the Vourla basin, and has evidently overflowed the intermediate portion of the bed of this ancient lake. The adjacent islands present phenomena resembling those observed in the neighbourhood of Smyrna, and originated, most probably, at the same period. A vast eruption of volcanic matter seems here to have burst through the bed of the ancient lake, uplifting the sedimentary matter deposited in it into hills and islands, which vary from 100 to 600 feet in height.

The two northern islands, Long Island and Keelsali, consist almost entirely of porphyritic trachyte and of a white tufa; but the small islands to the south are principally composed of the fresh-water deposits in contact with, and frequently disturbed by, similar igneous productions, offering clear evidence of their later origin. These volcanic ejections form part only of a chain of similar eruptions which extends to the north, nearly in a straight line, as far as the Gulf of Adramitti.

The fossils from the Vourla Islands have been examined by Professor Edward Forbes, and are described in a note appended to this memoir.

The Karabournou promontory consists of a high central table mountain of grey limestone, along the east and north base of which runs a narrow strip of the calcareous and marly series, the bed, no doubt, of an ancient lake which formerly occupied the whole Gulf of Smyrna, and, perhaps, the whole archipelago. The limits of this lake are indeed as yet undefined, but there are indications of it in the Scio and Mitylene channels, where it ranges at the foot of the higher hills along the present sea-coast, as on the east side of Karabournou. I obtained fossils (*Paludina*) proving its fresh-water origin at the very northern extremity of Cape Karabournou, and a few yards only from the sea.

On the western flank of the high central table of limestone lies a broad chain of hills, composed of shales and schists, which correspond with those of Mount Corax. They dip to the east and

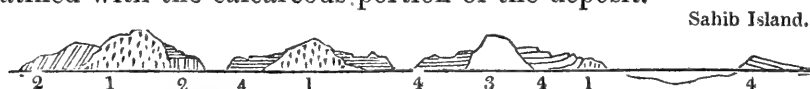
* The references both to this and the other sections are as follow : —

- | | |
|----------------------|---------------------------------|
| 4. Fresh-water beds. | 2. Shales and schist. |
| 3. Limestone. | 1. Erupted trap and serpentine. |

E. S.E., at an angle of from 45° to 60° , and, in both cases, pass beneath the intermediate mass of limestone which occupies the entire district between them. The limestone is, in general, a grey compact rock, but is sometimes crystalline, as, for instance, near Ritri, and Erythræ, at a spot noticed by Mr. Hamilton. The crystalline condition is probably due in this spot to the proximity of recent volcanic ejections of trachyte, &c., which occur abundantly in the neighbourhood.

In the western part of the Karabournou promontory are found also igneous rocks of two periods, the one antecedent and the other subsequent to the date of the lacustrine formations. The former is presented in a hill of serpentine, several hundred feet in height, near Cape Koumour Baba, the northern extremity of the promontory, and upon its sides rest in undisturbed succession the parallel layers of the several calcareous strata and marls deposited at the bottom of the lake; the shales in contact have been much disturbed and altered, and are indurated into slate hardly distinguishable from slates of the older rocks. The trap rocks of the latter period occur in four localities, in each of which they differ in their mineral composition: the first is found on the shore opposite to the Island of Sahib, and its intrusion has evidently accompanied the disturbance indicated by the considerable dip of the adjacent lacustrine deposits. The trap contains numerous small drusy cavities, in which is always found a singular fibrous mineral.

The lacustrine deposits correspond exactly with those of Vourla and of Smyrna, both in colour and mineral arrangement. In the island of Sahib there are some good specimens of pisolite, interstratified with the calcareous portion of the deposit.

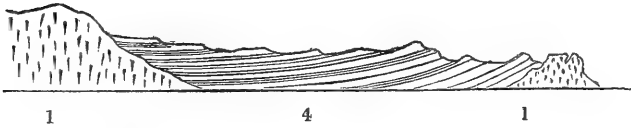


The above section exhibits portions of the whole series of rocks noticed in this paper. It illustrates the different ages of eruption and deposition; and commencing near the coast, about two miles to the west of Cape Koumour Baba (marked A on the map), it terminates at Sahib Island (marked B).

The next trappean rock is a peaked mass protruding from beneath the tertiary sediments at Cape Koumour Baba. These rocks are much contorted at the point of contact, but with the exception of appearing a little more indurated, they are not otherwise altered.

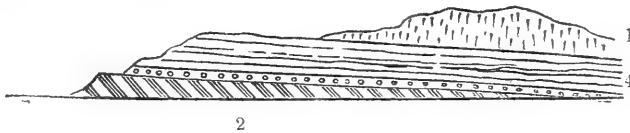


The above diagram exhibits a section presented in the cliffs that extend from the Cape about a mile to the westward, where their height is about 140 feet.



This section is exhibited in a line, drawn north and south, from the Cape to the serpentine hill, and goes through the fresh-water deposits. In this locality I procured one of the *Paludinæ*.

Following the coast down on the west side of the promontory, good sections of the shales and schists continue to be presented at every headland; but a few feet above the shore, under the village of Kutchuk Baghcheh, a small detached portion of the lacustrine deposit is again met with, extending for about half a mile in length and overlaid by a stream of brown trachyte, shown in the subjoined section.



This trachyte is similar to that which Mr. Strickland has remarked as occurring near Bournabat, and at Mount Pagus, above Smyrna. The trachyte contains fragments of an older basaltic rock imbedded in it.



The fourth example of the eruption of trappean matter is near the N.W. point of the bay of Erythræ, and is shown in the annexed section, which also indicates the relative superposition of the shales and limestone. The only difference between the former and those of Mount Corax is, that in the Karabournou district there is a larger proportion of jasper interstratified with the shales and schists. In every other respect it seems impossible to distinguish the rocks of the two localities.

Some time after making the observations in the Gulf of Smyrna above recorded, I had an opportunity of examining a portion of the coast opposite to Mitylene, near the islands of Adjano, where phenomena occur similar to those in the Gulf of Smyrna, viz. extensive trappean eruptions overlying portions of the lacustrine deposits, corresponding with those of Smyrna, Vourla, and Karabournou, and containing also black flints, as in all those localities, the identity being in every respect perfect. These beds, therefore, formed part of the great lake, although here the fossils were wanting. The trap forms a range of hills varying from 1000 to 2500 feet in height, extending from the Gulf of Sandarlic to the Mosconisi islands, at the bases of which the lacustrine deposits are occasionally visible. The largest portion of these is at Adjano, where the deposits dip under a high mountain of trachyte at an angle of 30°,

the trachyte being stratified like that found near Smyrna. The tertiary hills on the margin of the Scio channel, near the town of Tchesmeh, and in the island of Scio opposite to it, seem also to be of fresh-water origin, as they closely resemble those of the Gulf of Smyrna.

The facts made out from these investigations tend to prove the former existence of a large lake in the eastern part of the Archipelago, where the sea now attains a very considerable depth*, and that subsequently a succession of volcanic eruptions on a grand scale took place over the bed of the lake. A long period of tranquillity must, however, have preceded these eruptions, during which 500 or 600 feet of a vertical series of beds had been deposited throughout the lake. By this sudden outburst of igneous matter, parts of the deposit were raised into hills of considerable elevation, whilst the accumulations of the heated and melted fluids poured over the bottom, formed mountains and high ridges of considerable extent round each focus of eruption. In the tertiary hills there is evidence of a denuding power at elevations above the present sea level.

Having carried this ancient lake into the depths of the Archipelago, the question then arises as to its former boundary, a question which extended observations only can determine.

2. *Note on the FOSSILS collected by Lieut. SPRATT in the Fresh-water Tertiary Formation of the GULF of SMYRNA.* By Professor EDWARD FORBES, F.L.S.

LIEUTENANT SPRATT has found eleven species of fresh-water shells (all univalves) and a cast, apparently of a *Helix*, in the fresh-water limestone of Vourla.

Of these, two belong to the genus *Limneus*, one of which agrees with the *Limneus longiscatus* of the Paris basin and the Isle of Wight fresh-water bed, and the other is apparently the *Limneus ventricosus* of Brongniart; also a Paris basin shell.

Five species belong to the genus *Planorbis*. One of these is *Planorbis rotundatus*, a well-known eocene fresh-water fossil. Three are closely allied to, if not identical with, Paris basin fossils, and one is new.

Two belong to the genus *Paludina*. One of these appears to be the *Paludina atomus* of the Paris basin. The other is new.

One belongs to the genus *Melanopsis*. It is the *Melanopsis buccinoidea*, a species which, commencing its range in the oldest tertiary strata, has lived on to the present day, and is now a common inhabitant of western Asia, northern Africa, and the southern parts of Europe.

* At about five miles off the north extremity of Karabournou the depth is 100 fathoms, and continues to increase beyond.

One belongs to the genus *Melania*, and appears to be a new form.

On the whole, the evidence afforded by the fossils tends to show that the great fresh-water formation which skirts the Gulf of Smyrna and the coasts of many islands in the neighbouring portion of the Archipelago is of the age of the Paris basin and London clay. Whether the fresh-water tertiary basins of the interior of Asia Minor and of the valley of the Xanthus, and the islands of Cos and Rhodes, are of the same age, is very doubtful. Judging from the numerous fossils collected by Mr. Spratt and myself in those tertiaries, I am inclined to pronounce them of a different age and of later origin; anterior, however, to the pliocene marine formations of Asia Minor and the Sporades.

I may add that Mr. Strickland, in his Memoir on the Geology of Smyrna, mentions a *Unio*, a *Cyclas*, a *Helix*, and a *Cypris* in the tertiaries of Bournabat which have not been met with by Lieutenant Spratt.

Impressions of the leaves of vegetables, too imperfect for determination, accompany the specimens laid before the Society.

List of the Fossils.



- a.* *Planorbis Spratti* E. Forbes.
b. *Paludina Stricklandiana* E. Forbes.
c. *Melania Hamiltoniana* E. Forbes.

1. *Limneus longiscatus* Brongniart.

Many casts, not distinguishable from French and English examples.

2. *Limneus ventricosus* Brongniart?

The specimens closely resemble the recent *L. auricularius*. The spire appears rather shorter than it is represented in the figures of the French fossil, to which I have referred it.

3. *Planorbis rotundatus* Brong.

Such specimens as retain the shell exhibit transverse sulcations of growth.

4. *Planorbis cornu* Brong.?

Specimens with the shell are spirally striated, like the recent *Planorbis similis*. Not having compared it with authentic French examples, I have marked this species with a query, though it closely agrees with the figures.

5. *Planorbis prevostinus* Brong.?

Too imperfect a specimen for certain identification.

6. *Planorbis planulatus* Desh.?

The inner whorls do not occupy so much space as they are represented to do in the French figures. It is closely allied to the recent *Planorbis nitidus*.

7. *Planorbis Spratti*, nov. sp. (woodcut, fig. a).

P. testâ discoideâ (lævigatâ), superne planâ, inferne profunde umbilicatâ; anfractibus crassis, superne angustis, quinis, subangulatis.

Lat. $\frac{2}{10}$. Crass. $\frac{1}{10}$ unc.

Closely resembling the recent *Planorbis contortus*, which represents this species in miniature. It is allied to the *Planorbis cylindricus* of Sowerby, from the fresh-water tertiaries of the Isle of Wight, but differs in the greater number of whorls, and their narrowness on the upper disk, which is very slightly concave.

8. *Paludina atomus* Brong.

A little *Paludina*, which appears to be identical with the Paris basin shell described by Brongniart under the name of *Bulimus atomus*, and rightly referred by Deshayes to the genus *Paludina*.

9. *Paludina Stricklandiana*, nov. sp. (woodcut, fig. b).

P. testâ globulosâ, lævigatâ, politâ, umbilicatâ; spirâ depressâ, obtusâ; anfractibus 3—4; aperturâ ovatâ, superne angulatâ, marginibus crassis.

Lon. $\frac{1}{10}$ unc.

A very minute but beautiful and distinct species, in form somewhat approaching *Ampullaria*. Its nearest ally is the *Paludina globulus* of Deshayes, a Paris basin shell, which is, however, imperforate, and not nearly so globose as the Asiatic species.

10. *Melanopsis buccinoidea* Auct.

A single specimen from the burying-ground in the island of Vourla.

11. *Melania Hamiltoniana*, nov. sp. (woodcut, fig. c).

M. testâ ovato-turritâ, anfractibus septem, lævigatis, longitudinaliter multicostratis, costis subsinuatis.

Lon. $\frac{1}{4}$ unc.

Apparently a very fragile shell, of which usually only the impressions remain. In sculpture it bears a close resemblance to a marine *Chemnitzia*.

3. *On the Remains of FISHES found by MR. KAYE and MR. CUNLIFFE, in the PONDICHERY BEDS.* By SIR PHILIP DE MALPAS GREY EGERTON, M. P.

THE fish remains collected by Mr. Kaye and Mr. Cunliffe in the neighbourhood of Pondicherry having been placed in my hands for examination, I have endeavoured to discharge the task committed to me to the best of my ability, by comparing the Indian fossils with analogous forms from other localities, and with the figures and descriptions given by Agassiz in the "Poissons Fossiles." The collection consists wholly of teeth; they are, generally speaking, in bad condition, few of the placoid teeth retaining their bases, a very essential element in the identification and description of species. Before proceeding to detail the characters of the several specimens, it may be advisable briefly to relate the results at which I have arrived from the study of these ichthyolites. With the exception of two specimens, the collection is entirely composed of teeth of squaloid fishes. Of these two exceptions one belongs to the Ganoid order and to the family of *Pycnodonts*, and it is probably a *Sphærodus*; the other is referred to the Cycloid genus *Enchodus*, the teeth very closely resembling those of *Enchodus*.

halocyon, a species common to the chalk of England, continental Europe, and North America. Of the Placoid remains, two species only belong to the section of the Squaloid family with serrated teeth, and both of them are referable to the genus *Corax*, which Agassiz informs us is restricted to the chalk. One species is not distinguishable from *Corax pristodontus* of the Maestricht beds. The other is undescribed. The Squaloid teeth with cutting edges compose the bulk of the collection. They are referable to at least a dozen species, all corresponding in the absence of plaits or striæ on the surfaces of the enamel. Although there are close approximations amongst them to the species both of the Cretaceous and Miocene period, yet it is somewhat remarkable that I have not seen a feature nor a character which recalls in the remotest degree the forms of the Eocene period. They belong principally to the *Odontaspid* type; one species being closely allied to, if not identical with, the *Odontaspis raphiodon* of the chalk of Europe. Two or three species are referable to the genus *Otodus*, one approaching *Otodus appendiculatus*; also from the chalk. Of the genera found in the Pondicherry beds, the following is the stratigraphical distribution assigned by Agassiz. The genera *Lamna*, *Odontaspis*, and *Oxyrhina* extend from the recent period to the Greensand inclusive, the Jurassic species being now separated from *Lamna* under the generic title of *Sphenodus*, and from *Oxyrhina* under that of *Meristodon*. *Otodus* extends from the Crag to the Greensand, and *Corax* is restricted to the true chalk. The Ganoid genus *Sphærodus* ranges from the Tertiary beds to the Oolite, and the Cycloid *Enchodus* is restricted to the chalk. The distribution of species is as follows:—*Lamna*, 5 tertiary and 1 cretaceous; *Odontaspis*, 5 tertiary, 4 cretaceous; *Oxyrhina*, 11 tertiary, 2 cretaceous; *Otodus*, 8 tertiary, and 5 cretaceous; and *Corax*, 5 cretaceous. Of the five Placoid genera we have twenty-nine species occurring in the Supercretaceous, and seventeen in the cretaceous deposits; but not a single species has yet been found anterior to the latter period. The evidence, then, afforded by the Pondicherry fishes appears to yield strong corroborative testimony to the accuracy of Mr. Forbes's views, derived from the study of the invertebrate remains of the same locality; and I fully coincide with him in assigning these strata to the cretaceous period. I am, however, inclined, considering the number of species collected which must be referred to genera which we know decrease in species as they descend in the stratigraphical scale, from the occurrence also of Maestricht species, and from the presence of the genera *Corax* and *Enchodus* not yet found so low as the Neocomian, to place this deposit higher in the system than Mr. Forbes is inclined to do from his investigations. As I have above stated, the Placoid teeth are for the most part mutilated, rendering the generic identification a matter of much difficulty and uncertainty, although the specific characters are good and distinct. Agassiz says*, "It frequently happens that

* Poissons Fossiles, vol. iii. p. 266.

the root and the lateral cusps are detached from the dental cone, and in this case it is very difficult to distinguish *Otodus* from *Oxyrhina*. I shall describe hereafter several species very well characterised, but of which the genus is doubtful, because the perfect root is not known." Again, in prefacing the genus *Oxyrhina*, he says, "When the base of the root is mutilated, it sometimes happens that one is in doubt whether the species belongs to the genus *Oxyrhina*, *Lamna*, or *Otodus*." He also remarks, after comparing the genus *Lamna* with *Oxyrhina*, "The steps from *Otodus* to *Lamna* are more gradual, and here we find some species which are actually on the limits between the two genera." Some of the Indian species are in this category, for we find the principal dental cone of the form and aspect of an *Otodus* associated with the long pointed cylindrical lateral cusps of an *Odontaspis*, and the flattened cultriform tooth of an *Oxyrhina* furnished with smooth lateral cusps which exclude it from that genus. It is with much hesitation that I have ventured to draw up the following descriptions of the more perfect specimens of the Pondicherry collections, from a consciousness of my own inability to grapple with this most difficult branch of fossil Ichthyology, not unmixed with doubts of the stability of the generic and specific characters as at present acknowledged in the "*Poissons Fossiles*." Agassiz has himself complained of the paucity of materials for arriving at any very definite conclusions as to the variations of form in the teeth occurring in the various positions in the mouth of the same species. Those naturalists who have studied the recent sharks are well aware of the extent of those variations in a single individual, and can, therefore, appreciate the difficulties under which Agassiz has laboured in attempting a systematic arrangement of the fossil Squaloids. As I am in hopes this distinguished Ichthyologist will shortly have an opportunity of examining the Indian collections, I offer the following descriptions as provisional rather than final; or, at all events, as giving the characters of forms in themselves distinct, but which may hereafter be grouped together under legitimate generic and specific denominations.

CYCLOID ORDER.

Scomberoid Family.

ENCHODUS serratus Eg. — Three teeth from the Pondicherry beds, evidently belonging to the genus *Enchodus*. As I have before stated, they bear a very close resemblance to the species figured by Agassiz as *Enchodus halocyon*; at the same time (although the materials are too defective to warrant any definite conclusion), there are appreciable discrepancies of sufficient importance to induce me to abstain from identifying the Indian teeth with the species alluded to. The most perfect specimen, as compared with teeth of similar size of *E. halocyon*, presents the follow-

ing distinctive characters. The surface of the enamel is more smooth and even, in consequence of the fineness of the longitudinal striæ, which in *E. halocyon* are coarse and strongly marked. The transverse bands are broader, and the form of the teeth is less attenuated. The most important feature it presents is in the finely serrate cutting edge, which in all the specimens I have seen of *E. halocyon* is smooth and entire. A second fragment corresponds in all these points. The third specimen is a smaller tooth, and only differs from *E. halocyon* in the smooth and highly polished surface of the enamel. None of these teeth are perfect. The length of the largest is half an inch, of the smallest two lines.

GANOID ORDER.

Pycnodont Family.

SPHÆRODUS rugulosus Eg.—All the tritoral teeth in the Indian collections appear to belong to one species of the genus *Sphærodus*. A pretty group in Mr. Kaye's series shows nine teeth *in situ* of those in use, and underneath there are the germs of several of their successors. Three detached teeth appear to have belonged to the same specimen. In Mr. Cunliffe's collection I have found two tritores, considerably larger than the specimens alluded to above, but evidently belonging to the same species. In size these teeth resemble those of *Sphærodus Lens*, the smallest species figured by Agassiz; in regularity of form they approach nearer to *Sphærodus parvus*; but they are distinguished from these species and all others figured by Agassiz by the wrinkled or shrivelled appearance of the superficies of the teeth. This is visible even in the smallest specimens, and forms a well-marked and easily appreciable specific character.



PLACOID ORDER.

Squaloid Family.

CORAX pristodontus Agass. Poiss. Foss. vol. iii. p. 224. — A single fragment is the only evidence upon which rests the supposition that this species enjoyed the extended geographical range indicated by its occurrence in the Cretaceous system of Europe and India. This specimen shows the outer surface of the hinder portion of a sinistral tooth. The base is wanting. It corresponds in minutest detail with the analogous portions of a tooth received from Professor Goldfuss, named by Agassiz *Galeus* (now *Corax*) *pristodontus*, apparently from the Maestricht beds. A comparison with the figures given in the "Poissons Fossiles" yields a like result. Some specimens in Mr. Lyell's cabinet, from the

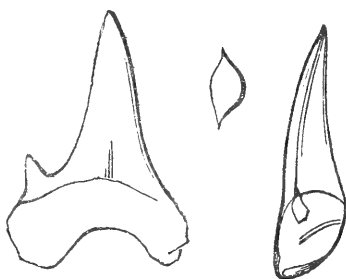


chalk of North America, approximate very closely to this species. Should they be identical, it will prove this to be one of the most widely distributed fossil forms of fishes with which we are acquainted.

CORAX incisus Eg. — A second species of *Corax* occurs in the Indian collection sent over by Mr. Cunliffe, of small size and very distinct character. It is rather smaller than the species of this genus generally are, corresponding in this respect with *Corax planus*, of which some imperfect specimens are figured in the "Poissons Fossiles" from an unknown locality. Our specimens are not perfect, but they are sufficiently so to prove them to be specifically distinct from all those figured and described by Agassiz. The principal cusp is conical, rather slender, and pointed. It is more upright and less falcate than usual. The antero-posterior diameter of the tooth is small, in this respect resembling *Corax planus*. The character of the marginal armature is peculiar. It is rather notched or crenulated than serrate, the subdivisions of the edge being blunt and irregular. The lateral cusp is smooth, and corresponds with its principal in the character of its dentelures.

OTODUS? marginatus Eg. — Several of the Indian squaloids are apparently referable to the genus *Otodus*. Of these, two have some resemblance to the common *Otodus appendiculatus* of the chalk formation; and although the characters of this species, as at present recognised, are wide enough to embrace an extensive variety of forms, yet they are sufficiently defined to exclude the Indian specimens. The larger species, of which I have found four specimens, is remarkable for the rapid increase of the antero-posterior diameter of the shaft as it approaches the base. The latter is thick and massive, with a deep depression on the outer surface. The cone in profile is regularly and distinctly incurved from the apex to the junction with the base. It is narrower than in most specimens of *O. appendiculatus*. The outer surface is smooth and rounded; the inner one is also smooth, and more arched than in any species I am acquainted with. A section, taken one third distant from the base, would represent the inner face of the tooth as nearly semi-circular. The cutting edge is sharp, and so distinct as to have the appearance of a border, separated from the remainder of the shaft by a shallow groove. The lateral cusp is large, conical, and sharp, having more resemblance in these respects to this feature in the odontaspid teeth. The corresponding cusp is broken; but the fracture shows that, in all probability, the tooth was symmetrical.

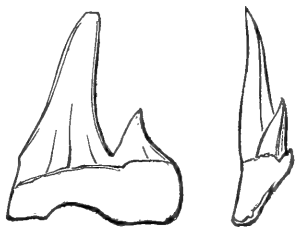
OTODUS basalis Eg. — A tooth sent to England by Mr. Cunliffe has a closer resemblance to *O. appendiculatus* than the species last



described. Of the various forms comprehended in this species, one fossil most nearly approximates a tooth from the Maestricht quarries. Its peculiar distinctive features are, the larger size of the lateral cusp, the greater breadth and obliquity of the base, and the smaller proportions of the principal cone compared with the other dimensions of the tooth.

When viewed in profile, the principal cone is straight and narrow, and the cusp from its inward slope forms an acute angle with the principal cone. Both surfaces are smooth and rounded; the inner are, as usual, rather more so than the outer. The tooth is slightly oblique, but not so much so as the Maestricht specimen. As this feature varies according to the position of the tooth on the jaw, it is of little value.

OTODUS nanus Eg. — A single tooth in Mr. Kaye's collection, referable to the genus *Otodus*, differs from the other species of the same genus in its diminutive size. The central cusp is triangular, equalling in height the breadth of the base. It has a thick and stunted aspect, being equally convex on either surface. It is incurved, and slightly obtuse at the apex. The lateral cusps are short, wide, and blunted.



OTODUS divergens Eg. — An unique specimen in Mr. Cunliffe's collection, although differing in some respects from the general characters of the genus *Otodus*, has notwithstanding more resemblance to this than to the squaloids of any other genus. The central cusp, from its sharp, flattened, and lanceolate form, resembles an *Oxyrhina* or *Lamna*; but the large development of the lateral cusps must exclude it from those genera. From *Odontaspis* it differs in the width and general character of the lateral cusps. The latter are exact miniature representations of the principal cusp, and are so placed upon the base as to slope outwards on either side. They have each a small supernumerary point on the outer shoulder. The tooth is slightly convex on both sides; the point is somewhat recurved; and the edges of all the cusps are remarkably sharp. This is a perfect and very interesting specimen.



OTODUS minutus Eg. — The last specimen I refer to this genus is of small size, not exceeding the dimensions of *Otodus nanus* described above, yet of different form. The principal cusp is more lanceolate, and the antero-posterior diameter is infinitely smaller, compared with the height of the tooth. The profile is straight, not incurved as in *O. nanus*. The lateral cusp is small and blunt. A prominent ridge borders the enamel at its junction with the base.



OXYRHINA triangularis Eg. — It requires specimens of unusual perfectness to enable the palæontologist to discriminate between the species of the genera *Oxyrhina*, *Lamna*, and *Otodus*. The Indian teeth,



being for the most part imperfect, it is a matter of great difficulty and uncertainty to decide to which genus many of them belong. The proposed arrangement of species must, therefore, be considered as a mere approximation, or rather, perhaps, as provisional, until more perfect specimens, or one more skilled in Fossil Ichthyology, shall clear up the obscurity. Several smooth teeth in the Indian collections are remarkable for their regular triangular form. They appear to have been destitute of lateral appendages. The base in this species is broad, equalling the total height of the tooth. The cone is flattened on the outer surface, and rounded on the inner. The enamel of the latter descends lower on the base at the sides than at the centre: the line of boundary thus represents an ascending obtuse angle. The teeth are more or less oblique according to the position they hold on the jaw. It is one of the smallest species of the genus.

LAMNA complanata Eg. — The occurrence of a small lateral cusp in some of the specimens of this species marks it as belonging to the genus *Lamna*, although in other respects it would more properly be considered as an *Oxyrhina*. Its nearest analogies are with *Oxyrhina xiphodon* and *hastalis*. It differs from the former in having the outer surface more prominent, and the inner one more evenly rounded without the flattened character of the basal portion of the enamel. From the latter it differs in the less prominent contour of the inner surface. It is distinguished from both by the presence of the lateral cusp, in being infinitely smaller, and in its slender and elegant proportions. The transverse section shows the antero-posterior diameter to be exceedingly narrow — more so, indeed, than in any other species of the genus.



LAMNA sigmoides — It is difficult in a mere verbal description to make intelligible the minute distinctions which, in considering the characters of the fossil squaloid teeth, are the elements on which the species are eliminated. A single tooth sent home by Mr. Cunliffe recalls at first sight the well-known *Lamna acuminata* of the British chalk. It approaches also that species in size, being one of the largest of the Indian specimens, which, generally speaking, are of unusually small dimensions. In form it is intermediate between *L. acuminata* and *L. cuspidata*.



It differs, however, from both in the sigmoid flexure of the cutting edge. There are no lateral cusps visible. In front it varies from the form of *L. cuspidata* in the greater breadth of the apex, and from *L. acuminata* in the parallelism of the sides in the middle region of the tooth. The outer surface is flattened until near the point, where it is slightly rounded. The inner surface is convex and prominent. Seen in profile, the cutting edge conceals the back of the tooth for two-thirds of its length; it then verges inwards until near the point where it again tends slightly outwards. The

base is partially concealed by the matrix; but it appears to have been furcate, and of rather small size.

ODONTASPIS constrictus Eg. — A very large proportion of the Indian odontolites belong to the species now under consideration. Out of some dozen of specimens I have not, however, found one having the base sufficiently perfect to show whether it supported lateral cusps or not. If they were present, they must have been of very small size. Under this uncertainty it is impossible to determine whether this species should be placed under the genus *Lamna* or *Odontaspis*; but I am inclined, from the slender subulate aspect of the teeth, to refer it to the latter. At the time of writing this, I have not been able to compare the Indian specimens with figures of *O. gracilis* from the chalk and *O. subulata* from the lower greensand of Neufchâtel; but the descriptions given of these species lead me to infer a considerable resemblance in size and form with the Indian species, although the latter has a very distinctive feature in the cessation of the cutting edges before they reach the base, giving a constricted appearance to the shaft of the tooth. This character is well marked in *Odontaspis contortidens* of the Molasse; indeed our Pondicherry fossils are only distinguishable from this species by the absence of the striæ on the inner surface of the teeth.



ODONTASPIS oxyprion Eg. — The last species I propose to describe in this memoir is also frequent in the Indian collections. It belongs without doubt to the genus *Odontaspis*, and is very nearly allied to *O. rhapsiodon*. The comparison, however, is less accurate than I could wish, owing to my not being able to refer to Agassiz's plate on the subject; but one character establishes at once the distinctness of the Indian species, viz. the absence of striæ on the inner surface of the tooth. Some of the specimens of this species are in a good state of preservation, showing the form of the base and the lateral cusps. It is not impossible that more than one species may be included in this description, as some of the specimens are more convex than others on the outer surface, and less recurved at the point. The number and form of the lateral cusps also vary considerably; but there is a general resemblance which induces me for the present to include all under one denomination. In the form of the central cone they agree very closely with *Odontaspis rhapsiodon*; but the lateral cusps are larger, more elongated, and sharper at the points, and in these respects they exceed even the recent *Odontaspis ferox*. They are sometimes single, sometimes double, on each side, and occasionally single on one side and double on the other. The base is broader and less deeply notched than in *O. rhapsiodon*.



A considerable number of specimens remain to be examined; but most of them will probably belong to one or other of the species described above. Should any distinct forms be found, they will be treated of in a future memoir.

4. *On the occurrence of a Bed of SEPTARIA, containing fresh-water Shells, in the series of Plastic Clay, at NEW CROSS, KENT.* By HENRY WARBURTON, Esq. M. P. F. R. S.

HAVING occasion, in the Spring of 1843, to travel along the South Eastern Railway, I observed at the distance of about 200 yards to the south of the New Cross Station, on the western side of the cutting which there lays bare the junction of the London and Plastic Clays, and at the very foot of that cutting, what seemed to be a continuous bed of stone, forming a part of the Plastic Clay series.

I applied, in consequence, to Mr. Simms, a Fellow of our Society, (who, as one of the resident engineers, had ready access to every part of the line), to procure for me specimens of this bed; and he not only complied with this request, but also made a vertical section of the beds exposed in the cutting, extending from the base of the London Clay to the bed of stone in question.

The specimens which Mr. Simms procured contain, imbedded in the substance of the stone, two fresh-water shells, a *Paludina* and a *Unio*, which Professor E. Forbes has examined and described. The stone proved, on examination, not to form a continuous stratum extending to any distance, but to occur at intervals only; and to be, in fact, a bed of *Septaria*, of a texture considerably more earthy than the *Septaria* of the London clay usually are. These *Septaria* may be traced along the base of the railway cutting from the point already mentioned, south of the New Cross Station, to beyond the first bridge which crosses the railway south of that station, and rising, like the railway itself, at an inclination of 1 in 100.

The position of this bed of fresh-water *Septaria*, in relation to the London clay, will be best understood from the following section by Mr. Simms:—

	Ft.	In.
1. London clay, the lowest bed of which, from 10 to 15 feet thick, is of a blue colour.		
2. Rolled flint pebbles - - - - -	1	10
3. Fine fawn-coloured sand - - - - -	0	3
4. Lignite - - - - -	0	0 $\frac{1}{4}$
5. Fine fawn-coloured sand - - - - -	2	0
6. Ferruginous sand, with fragments of oyster shells, and <i>Cerithia</i> -	0	4
7. Grey sand, with fragments of <i>Cerithia</i> - - - - -	0	8
8. Strong black clay - - - - -	0	10
9. Black clay and sand, with fragments of oysters and <i>Cerithia</i> -	0	9
10. Black sand - - - - -	0	4
11. Dark sand, with oyster shells - - - - -	0	6
	7	6 $\frac{1}{4}$
12. Calcareous stone, with fresh-water shells - - - - -	0	6
13. Sand and stone in a rotten state, with oysters - - - - -	0	3
	8	3 $\frac{1}{4}$

The following is the description of the shells, by Mr. E. Forbes :

1. *Paludina*.

A species with 5 ventricose whorls which appear to have been slightly striated by lines of growth; the largest perfect specimen measuring 1 inch in height by half an inch in greatest breadth of the body whorl.

I can find no character by which to separate this fossil from the existing *Paludina vivipara*; some of the southern varieties of which it closely resembles in external form. That species is very widely distributed, at present being common to a great part of Europe and Asia. I am not aware of its ever having been previously noticed as an older tertiary shell, but its allies, *P. achatina* and *P. unicolor*, are both recorded tertiary species, having a wide range both geologically and geographically; the identity of the living species with the fossils discovered by Mr. Warburton and Mr. Simms is thus rendered the more probable. I regard this species as quite distinct from the *Paludina fluviatorum* of the Wealden, which was confounded with *P. vivipara*, a confusion which has led to several erroneous statements and reasonings.

2. *Unio*.

An ovate, very inequilateral, depressed species, wrinkled transversely, growing to a length of between 2 and 3 inches.

The extreme difficulty of determining living species of *Unio* must render us very cautious in giving an opinion on a fossil. The remains, though not imperfect of their kind, and certainly those of *Unios*, are not sufficient to warrant the bestowal of a specific appellation on them. They are, however, probably distinct from any of the recorded British tertiary species. E. F.

I have only to add in conclusion, that in the Paris basin, which lies to the north of Paris, in the Département de l'Aisne, fresh-water shells belonging to the same genera occur in the plastic clay series, accompanied by lignite; and among the fossils of one of these beds, M. D'Archiac enumerates four species of *Paludina*, and an undetermined species of *Unio*. Mons. Charles d'Orbigny also, in a section of the beds in the Paris basin, intermediate between the calcaire grossier and the chalk, near Meudon, enumerates plastic clay, lignite with *Paludina* and *Anodonta*, and a conglomerate containing fresh-water shells.

This point of correspondence between the plastic clays of England and France, viz. their containing several of the same genera, at least of fresh-water shells, besides *Cyclades*, which have been before noticed as common to the two, and *Cerithia*, and other shells, inhabitants of brackish water, I have thought of sufficient interest to make the subject of a notice to the Society.

MAY 1. 1844.

1. *Report on the FOSSILS from SANTA FE DE BOGOTA, presented to the Geological Society by EVAN HOPKINS, Esq. F.G.S. By Professor EDWARD FORBES, F.L.S.*

THE fossils from Bogotá presented by Mr. Hopkins are all remains of Mollusca. They are embedded in a very dark and compact limestone; and are all, apparently, from the same formation. They include 17 species, most of which are in very good preservation. Of these, 9 are described species, and are identical with fossils from the same neighbourhood, described in the memoir by M. Von Buch, "On the Fossils collected in America by MM. Humboldt and Degenhardt," in the paper entitled "Notice of the Oolitic Formations in America," by Mr. Isaac Lea, printed in the "Transactions of the American Philosophical Society for 1841," and in the account of the fossils collected in Columbia by M. Boussingault, given by M. Alcide d'Orbigny, in the Palæontology of his South American Voyage, published in 1843. All these papers have been consulted in the preparation of this Report.

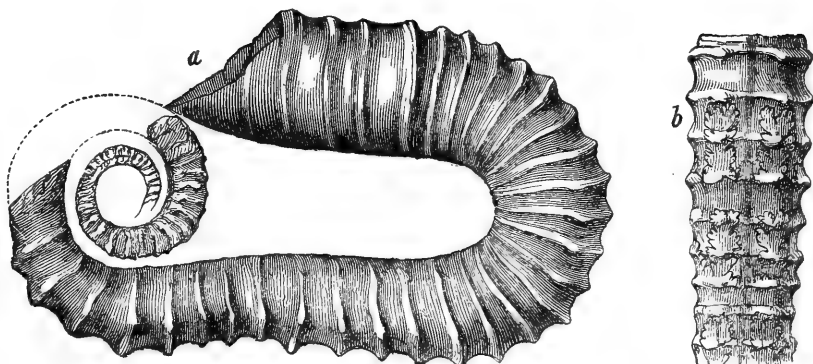
The formation in which these fossils were found has been referred by M. Von Buch to the Cretaceous era, by Mr. Lea to the Oolitic period, and by M. d'Orbigny to the Neocomian epoch of the Cretaceous era. The result of an examination of Mr. Hopkins's specimens, more especially of such as are new, bears out the view of their cretaceous origin first taken by M. Von Buch, and afterwards adopted by M. d'Orbigny. It is probable, however, from the number of forms approximating Gault species, that the last-named palæontologist has placed them too low in the Cretaceous series, when he refers them to the Neocomian, or, in other terms, the lower part of the lower greensand strata.

Accompanying the shells is a specimen of coal, stated by Mr. Hopkins to be found in the same formation. The species in the Society's collection are mostly Cephalopoda; they consist of 10 Ammonites, 1 Ancyloceras, and 2 Hamites; these are accompanied by 1 Rostellaria, 1 Venus, 1 Lucina, and 1 Inoceramus.

DESCRIPTIVE LIST.

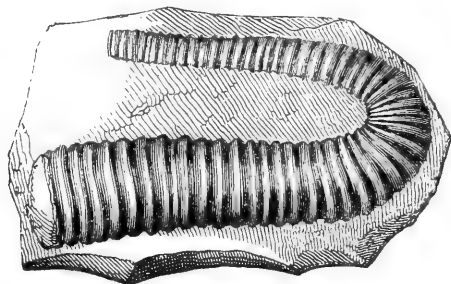
1. *Ancyloceras Humboldtiana*. (*Orthocera Humboldtiana* Lea, loc. cit. p. 253. pl. viii. f. i.)

This is apparently a good (though not quite perfect) specimen of the fossil described by Mr. Lea as an *Orthoceras*, from a fragment. The turns of both extremities are seen in Mr. Hopkins's specimen.



- a. Side view, the outline completed by a dotted line.
 b. View of the back, to show the form of the septa.

2. ? *Hamites Degenhardtii* Von Buch. l. c. f. 23, 24, 25.
 3. *Hamites D'Orbignyana*. Nov. sp.

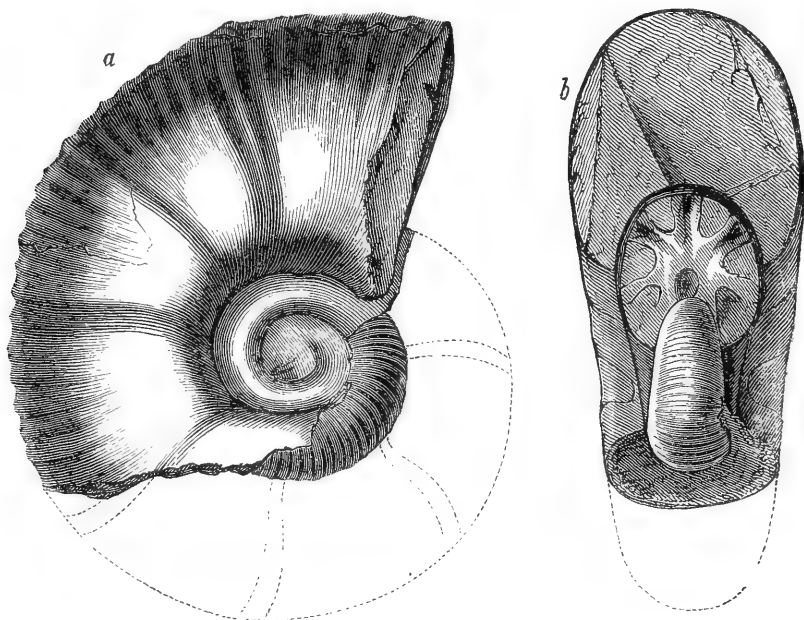


H. testâ tereti, transversim sulcatâ; sulcis numerosissimis, æqualibus, regularibus; interstitiis elevatis, angustioribus, acutiusculis.

Length of anterior portion	-	-	-	$1\frac{6}{10}$ unc.
posterior portion	-	-	-	$1\frac{4}{10}$ „
Breadth of widest part	-	-	-	$0\frac{4}{10}$ „

Of this Hamite there is a single specimen which exhibits most of the essential parts of the shell. It is cylindrical and tapering; the oral extremity appears to have been somewhat inflated. The surface is furrowed by numerous transverse sulcations, which are continuous to the back, though not in all cases equal; they are separated from each other by somewhat acute ribs. The shell bends with a sudden curve, and is then produced into a rapidly diminishing posterior extremity, running nearly straight and parallel with the oral portion.

4. *Ammonites Dumasianus* D'Orbigny, l. c. p. 69. t. ii. f. 1—2.
 5. ——— *galeatus* Von Buch. l. c. pl. 2. f. 20.
 6. ——— *Alexandrinus* ? D'Orbigny, p. 75. pl. xvii. f. 8—11.
 7. ——— *Vanuxemensis* Lea ? pl. viii. f. 5.
 8. ——— *Rhotomagensis* Sow. (Noticed also in the memoir by M. Von Buch.)

9. *Ammonites Hopkinsi*. Nov. sp.

- a. Side view, showing the outline complete and a portion of the shell.
 b. View showing the lobes in the septa.

A. testâ crassâ, umbilicatâ, transversim sulcatâ costatâque; sulcis 6, subundulatis, marginatis; dorso rotundato, transversè costato; costis inter sulcos 5—8, rotundatis, lateraliter obsolete; aperturâ ovato-lunatâ; septis—.

Diam. $2\frac{1}{2}$. Crass. $1\frac{6}{10}$ unc.

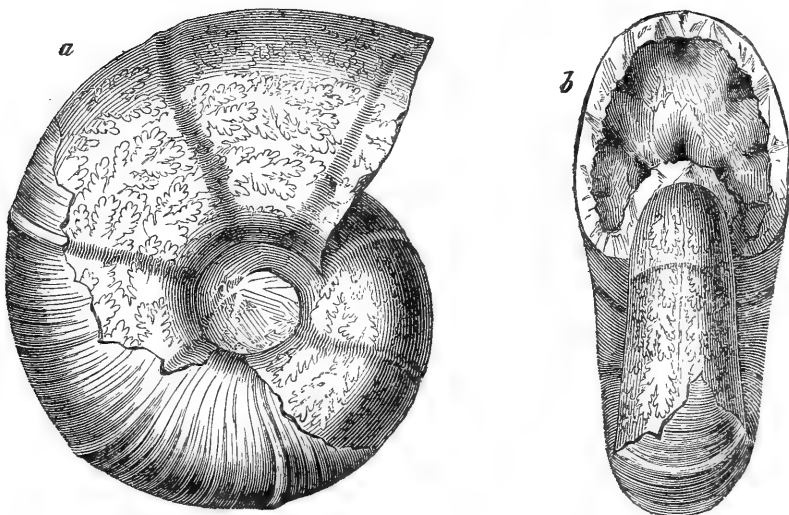
This fine Ammonite has an inflated shell, which appears to have been of considerable thickness. The outer whorl does not entirely conceal the others, but leaves a deep umbilicus which in the perfect shell probably exposed several of the inner volutions. The sides of the whorls forming the boundary of the umbilicus are steep, in consequence of sudden inflections of the shell. The middle of the whorls is flat and nearly smooth; the back is rounded, and transversely sulcated, with rather broad, slightly undulated shallow furrows, which are separated into groups of from five to eight by distant, wider, and deeper furrows, which run in a curved manner entirely across the whorls. These sulcations, marking stages of growth, are very strong on the cast, but comparatively slightly marked on the external surface of the shell, showing that they are the marks of internal ribs. The mouth appears to have been lunate, and slightly elongate. It belongs to the section *Ligati*. It is very nearly allied to an Ammonite from the lower greensand of Southern India.

10. *Ammonites Inca*. Nov. sp.

A. testâ crassâ, umbilicatâ, radiato-striatâ, sulcatâ; sulcis undulatis 6; dorso rotundato; aperturâ lunatâ, latâ; septis pinnatis, multilobatis.

Med. semi-diam. $1\frac{2}{10}$. Ult. anf. $1\frac{6}{10}$. Crass. $1\frac{4}{10}$ unc.

This species is nearly allied to the last, and resembles it in form, but differs in the absence of smaller sulcations between the greater furrows, which divide the cast of the outer whorl into six wide divisions, and which on the external surface of the shell were marked by raised ribs. These furrows and ribs proceed in an undulate and rotate manner from the umbilicus, which appears to have partially exposed the inner whorls. The sur-

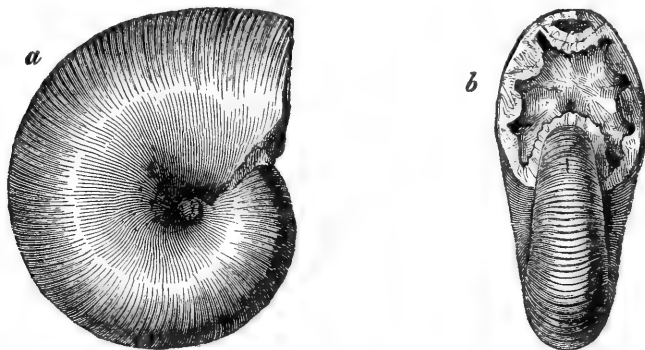
*Ammonites Inca.*

- a.* View of the side, showing the shell and the septa.
b. View showing the lobes of the septa.

face of the shell was finely, though irregularly, striated in an undulated manner, indicating fine lines of growth. The sides of the umbilicus are steep; the mouth is lunate, and broader than long.

The sutures of the chambers are well seen on a small specimen. The lateral lobes, of which four appear on the lateral portion of the outer whorl, are bilobate and pinnate, the pinnæ being denticulate. The dorsal lobe is short, linguiform, and denticulate at the sides.

Nearly allied to *Ammonites latidorsatus* Michelin, a gault species. Belongs to the section *Ligati*.

11. *Ammonites Buchiana*. Nov. sp.

- a.* Side view.
b. View of the back.

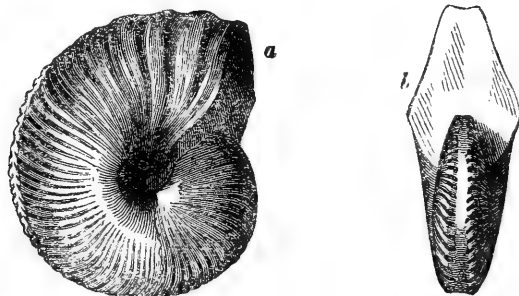
A. testâ subdepressâ, subumbilicatâ, involutâ, dorso rotundato, costis transversis numerosissimis subundulatis, ad lateras obsolete; circa umbilicum lævigatâ. Aperturâ lunatâ. Septis —

Med. semi-diam. $1\frac{6}{10}$ unc. Crass. $1\frac{3}{10}$ unc.

The *Ammonites Buchiana* is a very beautiful species. The outer whorl almost completely envelopes the others so as to leave only a small but deep

umbilicus. The surface around the umbilicus is smooth for about half way across the whorl, where very numerous, regular, rather shallow, somewhat undulated striæ, or narrow sulcations, commence, with narrower interstices, and continue across the rounded back. The mouth is ovato-lunate; the septa appear to have been arranged in numerous phylliform lobes, the terminal divisions of which were ovate and large. Belongs to the section *Heterophylli*, but is rather an abnormal form.

12. *Ammonites Leai*. Nov. sp.



a. Side view.

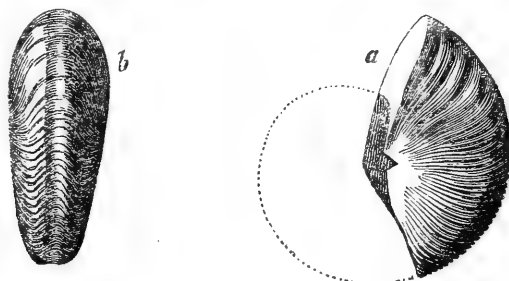
b. View showing the form of the aperture, and the back of the whorls.

A. testâ compressâ, subumbilicatâ, involutâ, semicostatâ, costis numerosis, prope aperturam obsoletis, sulcis undulatis substitutis; dorso excavato-sulcato, sulco laevi, marginibus carinatis, dentatis. Aperturâ subtriangulâri. Septis——

Med. semi-diam. $0\frac{6}{10}$; m. crass. $4\frac{1}{2}$; lat. sulc. dors. $0\frac{3}{4}$ unc.

A very beautiful little Ammonite, quite perfect, and apparently full-grown. It is compressed at the sides, and flattened and furrowed at the back. The last whorl envelopes the others, and becomes somewhat dilated at the mouth. That half of it nearest the umbilicus is smooth, the remainder marked by numerous well-defined undulated sulcations, which become obsolete towards the mouth, where they are replaced by deeper and wider sulci, separated by flattened elevations of equal breadth. The angles of the dorsal furrow are rather acute, and are tuberculated by the raised oblique extremities of the costæ between the lateral sulcations. The centre of the back is slightly hollowed out, and quite smooth. The mouth is wide and triangular, though truncated at the top. The septa are not visible. Belongs to the section *Dentati*, and is nearly allied to several gault Ammonites.

13. *Ammonites bogotensis*. Nov. sp.



a. Side view; the outline of the complete shell restored.

b. View of the back.

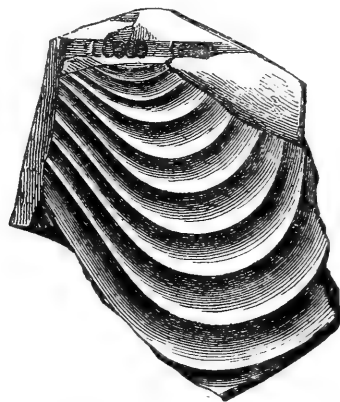
A. testâ compressâ (subumbilicatâ?) radiato-striatâ, subsulcatâ, dorso plano subexcavato, sulco dorsali lato, laevi.

Lat. frag. $1\frac{2}{12}$.

Crass. $0\frac{7}{12}$ unc.

There is only a fragment of this Ammonite in the collection. It presents, however, excellent distinctive characters in the outer whorl, which is compressed, and so large as apparently to have enveloped, or nearly enveloped, the others. It is marked with radiating striæ or rather furrows, which are unequal and slightly undulated. These are separated into groups by wider, distant, shallow sulcations. The back is flattened, slightly excavated, and bounded by an obsolete keel or angle at each side, over which the lateral striæ turn obliquely, but become obsolete before they reach the hollow of the centre, which appears to have been smooth. The aperture was probably ovato-lunate in form. Belongs to section *Dentati*, and is nearly allied to several gault species.

14. *Rostellaria angulosa* D'Orbigny, l. c. pl. xviii. f. 4.
15. *Lucina plicato-costata* D'Orbigny, l. c. p. 83. pl. xviii. f. b. 4.
16. *Venus chia* D'Orbigny, l. c. p. 82. pl. xviii. f. 9, 10.
17. *Inoceramus lunatus*. Nov. sp.



I. testâ suborbiculari, obliquâ, planâ, sulcis concentricis regularibus latis, interstertiis angustis elevatis acutiusculis.

The only specimen of this well-marked *Inoceramus* is imperfect. The characters of the surface are, however, well displayed, and a portion of the hinge is shown. The sulcations of the surface are lunate, broad in the centre, narrow at the sides, and very regularly formed. The intermediate ribs are narrow, and slightly or obsoletely ridged; they slope away into the furrows more suddenly anteriorly than posteriorly. The fragment measures $1\frac{1}{2}$ inch in length, by $1\frac{3}{10}$ in breadth.

2. Comparative Remarks on the Sections below the Chalk on the Coast near HYTHE, in KENT, and ATHERFIELD, in the ISLE of WIGHT. BY W. H. FITTON, M.D., F.R.S.

My objects in this paper are to illustrate, 1st, two sectional elevations, showing the proportional thickness of the principal divisions of the strata at Hythe and Atherfield; 2dly, an approximate sketch of the cliffs from Atherfield to the East of Blackgang-Chine; and 3dly, a corresponding sketch of the section from the chalk hills above Folkstone, to the level of the sea at Hythe.

§. The Atherfield Section is a copy of a drawing made by Sir John Herschel, referred to in the fourth volume of the Geological Transactions*: I have engrafted upon it such farther information as has

* Second Series, vol. iv. p. 186.

been recently obtained, as well as the result of Mr. Simms's measurement ; and shall now mention some of these additions, beginning at the junction of the Lower Green Sand with the Wealden, and referring for an account of the junction itself to the abstract published in the "Geological Proceedings," vol. iv. p. 198. The subdivision of the strata into groups is, of course, in a great measure arbitrary, and would, in all cases, probably vary, according to the views of different observers, and to the temporary condition of the cliffs, which are in a constant state of degradation and change.

§. Although the two lower beds immediately over the Wealden are not together more than 5 feet in thickness, it will be expedient to consider them separately, both on account of the great number of very remarkable fossils which they contain, and of their difference, both in composition and fossils, from the beds of clay immediately above, — which nearly resembles fullers' earth, and differs much in its characters from the sandy clay or mud immediately in contact with the Wealden. It is not improbable that these two lower beds at Atherfield may be the representatives of some more largely developed group at the bottom of the Green Sand in other countries.

The absence of strata corresponding to these lowest beds, in the clay immediately above the Wealden at Hythe, is remarkable ; but the bottom of the series in Kent is hitherto known only from the specimens obtained from Mr. Simms's shaft. It is much to be wished that this part of the section may be brought into view by an open cutting, for which the vicinity of the town of Hythe affords many promising positions.

The list of fossils from the coast at Atherfield has received several additions since my last communication ; among others many excellent specimens of *Perna Mulleti* have been obtained, by which some new points in the structure of that remarkable fossil are supplied. The whole collection of fossils from this place has been examined and named by Mr. Forbes.

§. With respect to the clay to which the name of "fullers'-earth" has here been assigned, I wish to correct a statement in my former paper (Geol. Trans. 2d ser. vol. iv. p. 196.), where it is said that "the lowest stratum of clay immediately above the fossiliferous stone at Atherfield appears to be the equivalent of the fullers'-earth of Surrey," and that the stone itself, about 2 feet in thickness, "is apparently the equivalent of the limestone very near the bottom of the Lower Green Sand at Hythe." This clay, though it has many of the properties of fullers'-earth, is certainly not the representative of the substance which bears that name at Nutfield and Reigate, in Surrey ; and the stone beneath is quite distinct from the Kentish Rag of the Hythe quarries. I was led into both these errors by an imperfect acquaintance with the bottom of the section at Hythe ; by the (supposed) absence there of fullers' earth above the limestone ; and by finding at Atherfield *Nautilus radiatus* (?), with *Trigonæ* and other fossils of frequent occurrence in the Hythe stone quarries. The true place of the fullers'-earth, at Nutfield itself, is above the Kentish Rag, and considerably above the bottom of the Lower Green Sand.

The junction of the Lower Green Sand with the Wealden on the south of Nutfield was disclosed by the cutting for the railway near Robert's Hole Farm, as mentioned in my last paper. On the N. W. of this farm, a flexure or depression of the strata brings down one of the principal beds of fullers' earth to the level of the railroad, near the Redhills (or Reygate) station; and this was exposed, some months ago, in a bank immediately behind the original Station House* of the South Eastern Company.

I have hitherto seen no traces of this upper fullers' earth at Hythe; but at two intermediate points, viz. Tilburstow Hill, near Godstone, and the top of Mrs. Bensted's principal quarry, near Maidstone, fullers' earth appears with somewhat peculiar characters, above the mass of stone, which has been considerably disturbed at both places. A few feet (10 or 12) below this fullers' earth at Tilburstow†, portions of white or yellowish sand in a stemlike arrangement occur, precisely resembling what I shall presently mention as fallen from the upper part of the cliffs on the east of Whale-Chine near Atherfield. If these appearances in Kent and Surrey mark the top of the limestone, they may possibly indicate a corresponding point in the Atherfield section.

§. A continued search has brought to light many specimens of fossils, among which are several new species, in a bed which seems to be immediately above the fullers' earth of Atherfield Point. They were described to me as occurring in detached masses or lumps in the sandy clay immediately under the lowest range of larger concretionary masses which form the prominence of the coast at the "Crackers." The fossils are united by a medium which varies from a loose sand to a somewhat calciferous stone, or indurated fullers' earth. These lumps may, possibly, be the representative of the masses which are mentioned by M. Leymerie as occurring in the "Argiles Ostréennes," of the department of the Aube.

§. The "*Crackers*" is the name given to a projecting part of the coast, which owes its prominence to the presence above the level of the sea of two ranges of nodular masses, occurring in a bed of sandy clay about 18 or 20 feet in thickness, and at the junction of which with the sandy stratum next below the *Ammonites Deshayesii* was frequent. These nodules of sand and calciferous sand-rock are the only stone upon the coast which can be considered as representing the (Kentish) limestone of Hythe and Maidstone, &c.; and their distance from the bottom of the Lower Green Sand accords with this identification.

The vertical distance from the bottom of the Crackers to the

* This Station has since been removed to the Junction with the Brighton Railway.

I find from the Railway Plan of the country near Redhills and Nutfield that Mr. Simms has estimated the height of two of the fullers' earth pits nearest to Robert's Hole Farm at 140 and 160 feet above the junction of the Lower Green Sand and Weald clay, which has afforded the *Perna Mulleti* and other remarkable fossils of Peasmarsh and Atherfield.

† See Account of Tilburstow. Geol. Trans. vol. iv. p. 138.

Wealden is about 59 feet, according to Mr. Simms ; nearly the same thickness as of the corresponding portion of the section at Hythe.

§. The aspect of the shore from the Crackers eastward is diversified only by the presence of an undercliff, which varies in extent from the rapid destruction to which every part of this coast is subject. At *Atherfield-high-cliff*, between 500 and 600 paces from the Crackers, is a fossiliferous group, the top of which descends thence to the shore at a distance of more than 250 paces ; and includes several remarkable ranges of *Gryphæa sinuata*, among which are very fine specimens with large *Ostrea* ; the lowest bed of this group also consists of a similar range, and immediately beneath are masses composed for the greater part of agglutinated shells of *Terebratula sella*, with another (plicated) species.

To compare the two sections at this point, let us suppose a limestone as thick as that of Hythe (about 130 feet), to be introduced in the place of the Crackers. This, from the inclination of the strata, would extend along the coast to a point about 300 paces east of Whale's Chine ; and would include the fossiliferous nodules of the Crackers at the bottom, and also, near the top, another nodular mass of strata which rises to the summit of Atherfield-high-cliff. The contents of this latter group are, as yet, imperfectly known ; but the fossils hitherto found on this part of the coast are nearly the same with those of the quarries at Hythe.

The strata from hence to Whale's Chine consist, generally, of a greenish sandy mud, including several ranges of *Exogyra*, with other fossils, one of which crosses the mouth of that chine, and is visible within the chasm itself, descending to the shore at a point very near the mouth of the next chasm on the east called Ladder Chine.

Another group, containing nodular concretions, is visible on the east of Walpen Chine, beneath what is called *Walpen high-cliff* : it first rises on the east about 350 paces from the chine, and extends to a distance answering to about 200 paces eastward. A second remarkable group containing *Gryphæa* rises between Walpen high-cliff and Cliff-end.

The beds above Cliff-end to the top of Black-Gang-Chine have hitherto afforded few fossils ; but in the corresponding part of the section, from Bonchurch to Shanklin, the upper beds are much better displayed, and deserve a new examination. They contain numerous casts, chiefly those of *Gervillia aviculoides*, *Natica*, *Rostellaria*, *Thetis minor*, *Terebratula*, *Trigonia alæformis*, *Turbo*, and *Venus* ; and the shore immediately on the east of Shanklin-Chine exhibits, at low water, an extensive surface of a lower bed, almost entirely composed of large *Gryphæa sinuata*.

§. The distinction between the first and second subdivisions of the Lower Green Sand, pointed out in my description of the coast near Folkstone, is much less prominent near Atherfield than in Kent : but a group corresponding to the upper or ferruginous division (which Mr. Austen mentions as conspicuous also in Surrey) is clearly distinguishable at the farm of Walpen, where a continuous ridge of sand impends over the lower ground between

that place and the coast. A great portion of the two promontories at Black-Gang-Chine belongs to this upper division ; and if the interval between the bottom of the Gault within the chine and the retentive stratum over which the streamlet runs to the waterfall, be assigned to it, the thickness will be rather more than 200 feet, including some remarkable beds — one 12 feet, and two others about 17 feet each, in thickness — of fawn-coloured, or nearly white, sand, not in itself distinguishable from that of Hastings. No fossils from this division in the Isle of Wight have yet come to my knowledge. Its junction with the more retentive mass below appears to be marked by the breaking out of springs, as in the corresponding place near Hythe. The subdivisions of this group are detailed in the drawings.

On the coast of Kent, between Folkstone and Sandgate, this upper division of the Lower Green Sand contains more calcareous matter than at Black-Gang-Chine, and even some concretions of compact limestone, with spongy siliciferous masses, very like the whetstone of Blackdown. [Geol. Trans. 2d Ser. iv. p.118, 119.]

§. *The Gault*, hitherto estimated as no more than 70 feet in thickness throughout the back of the Isle of Wight, appears from Mr. Simms's measurement to be 146 feet thick near Black-Gang-Chine. The lower part is at first view not easily distinguished, from its change of colour after exposure ; but the lower line of boundary was accurately traced, on the east of the hotel, by Mr. Warburton, and on the west of it by myself, within the upper part of the chine on both sides. On the west of the hotel, just within the ravine, at the top, some of the characteristic Gault fossils, including Ammonites, have been found close to the bottom of the deposit ; and similar remains have been obtained, as I am informed, at Puckaster.

The much greater prominence of the *Upper Green Sand*, which has here a thickness of 104 feet, is a very remarkable point of difference from the Folkstone section. This group in the Isle of Wight consists apparently of two divisions, as in Western Sussex, and contains fossils in great numbers.

§. On a general comparison of the sections of the Kentish coast and the Isle of Wight, the most prominent points of difference are, 1st, the almost total absence of limestone at Atherfield ; and 2d, the great excess, at the latter place, in the thickness, especially of the Lower Green Sand. —

					Atherfield.		Hythe.	
Thickness of Upper Green Sand	-	-	-	-	104	0	15	0
„ Gault	-	-	-	-	146	0	126	0
„ Lower Green Sand	-	-	-	-	752	11	406	6
Total	-	-	-	-	1002	11	547	6

So that, while the Gault in the two situations differs only 20 feet in thickness, the Lower Green Sand at Atherfield exceeds that of Hythe by 346 feet. There is also throughout considerable variation in mineral composition, and in aspect ; but not greater than what

appears, even in the Isle of Wight itself, between the nearly horizontal strata at Atherfield and Shanklin, and their continuation in the vertical strata at the Red-Cliff between Sanddown and Culver. The distance in a direct line of the two sections we have just compared, from Atherfield to Hythe, is less than 95 miles; while that of their foreign equivalents is, — in the case of the Aube, about 285 English miles; from Atherfield to Neufchâtel is about 440 miles; to Hanover the distance is not less than 450 miles; and to the Crimea is 1650 miles. From the Neufchâtel deposit, which M. Dubois has emphatically identified with that of the Crimea, the distance is not less than 1300 miles.

§. Such being the strata in the two principal sections of our coast, let us next enquire what are their equivalents in other parts of the globe. This question has of late acquired new importance, from the proofs of the wide diffusion of the cretaceous system, and the almost surprising agreement of its fossils in very distant places.

A brief general statement concerning the *Terrain Neocomien* has been given by Mr. Murchison in his Address to the Geological Society at the Anniversary of 1843. It may be useful to bring together some of the descriptions of those distant deposits, though it would be difficult in a small compass to give even an abstract of the various papers on the subject published during the last ten years. I have therefore given some of the principal characteristics of the groups, following as authorities, — 1st, the original memoir of M. Montmollin, on the cretaceous deposit of Neufchâtel, from whence the term “Neocomien” has been derived; 2dly, that of M. Leymerie on the department of the Aube in France, accompanied by a series of plates; 3dly, M. Roemer’s elaborate work, on the fossils of the chalk formation in the North of Germany; 4thly, the account given in M. Dubois de Montpereux’s work on the Crimea, of the cretaceous series in that region.

The deposit since called “Neocomien” on the Continent was first described by M. Auguste de Montmollin, in a paper published in 1835.* The author states that he first learned at Paris in 1828 that fossils collected by him in the vicinity of Neufchatel belonged to the lower part of the chalk formation, “the green sand,” although previously considered as a part of the Jura formation. The term “*Neocomien*” was applied to these strata by M. Thurmann, and subsequently recognised by M. de Montmollin, who had previously designated his discovery merely as the “Terrain crétacé de Neufchâtel.”

The strata described by M. De Montmollin were unconnected with any superior groups; but M. Dubois subsequently discovered at Souaillon, traces of green-sand above the yellow limestone. The list of fossils from Neufchâtel was unaccompanied by plates; and it was not till those of M. Leymerie appeared, that any figured Neocomian fossils were known in this country, although many of

* Mém. de la Société de Neufchâtel, vol. i. p. 47.

those named by M. Montmollin belong to our green sand. M. Leymerie, though he regards the aspect of the Neufchâtel series as quite distinct from that of the Aube, considers the two deposits as perfectly identified by their fossils. The limestone below the "*Marle bleu*" of Neufchâtel either does not appear in England, or is represented by the two lowest beds at Atherfield, so remarkably abundant in fossils. If this be the case, our fullers' earth at Atherfield and Hythe may represent the blue marl (30 feet in thickness), and our *Kentish* limestone (129 feet), at Hythe, may be the equivalent of the upper "yellow limestones," from 120 to 160 feet thick.

§. A very important extension of the tract occupied by the Neufchâtel deposit has since been made known by M. Jules Itier, in a memoir read before the Institute of France *; from the report on which it appears that the Neocomian strata in the department of the Aisne have a maximum thickness of 300 *metres*; which, the reporter adds, is far inferior to that of the same formation in the department of the Isère, and of the South of France. Among the fossils of this department, the most remarkable and characteristic is the *Chama ammonia* (Caprotina of D'Orbigny), from whence, or rather from its synonyme *Diceras*, the term "*calcaire à dicérates*" has been applied to some lower members of the chalk series, in what has been called the "bassin méditerranéen."

§. To any one familiar with the chalk districts of England, and those of France near the coast of the English channel, it would be surprising if the series of beds below the chalk on the east of Paris were very different from that of the west. M. Leymerie's map of the department of the Aube appears to indicate the same series as that of England; yet it is difficult to identify his subdivisions at the upper part of the series with ours. His general divisions of the subcretaceous groups are, *Argile-teguline* and *grès vert*, about 150 metres (about 490 feet); and *Terrain neocomien*, 50 metres (164 feet); the latter including three subdivisions, which seem to be the equivalents of part of our green sands, — viz. *a. Argiles et sables bigarrées*, containing much iron ore; *b. Argiles ostréennes*, (about 25 metres); *c. Calcaire à spatangus*, about 13 metres (about 42 feet).

§. In confirmation of the evidence which proves the superposition of our English equivalent of the Neocomian to the Wealden group, it may be remarked, that the fishes of the latter deposit are considered by M. Agassiz as more intimately allied with the oolitic than with the cretaceous series; and a similar observation has been made by Professor Owen with regard to the Wealden reptiles. If, therefore, a *marine* equivalent of our Wealden should be discovered, analogy would lead us to expect in its fossils a character approaching to that of the *Oolites*, from which M. D'Orbigny regards the whole of the cretaceous species as perfectly distinct:—and for such a deposit the best name would probably be that of "*Ma-*

* Comptes rendus, &c. de l'Acad. 22 Août, 1842.

rine Wealden" (*Veldien Marin*) which would at once indicate its position, and its peculiar relations.*

§. The lower cretaceous series on the Continent, which probably bears the greatest analogy to ours, is that of Hanover, described by M. Roemer. Though differing at the upper part from ours by the absence of the Gault, the cretaceous series at the bottom is well defined, reposing on a complete equivalent of our Wealden, with nearly all the characteristic fossils of Surrey and Sussex. It is not easy to identify the upper member, which M. Roemer supposes to be the same as the upper part of our Lower Green Sand, but which contains a great variety of fossils, and possibly may include some higher portions of the chalk.

The "*Hils-conglomerat*" of Roemer contains some fossils identical with those of our Lower Green Sand, and some with the Neocomian, which he distinguishes from that division. It is *supposed* to rest upon the lower clay of Hils (Hils-thon), but has not been seen in apposition with it. Lastly, the Hils-thon is identified by its fossils with the *Speeton clay* †, and seems to correspond exactly with the clay of Atherfield, Hythe, and Surrey. Having had the pleasure of seeing M. Roemer in his own country during the progress of his work, and having mentioned to him the probable identity of our Atherfield clay with that of "Hils," I am glad to find (p. 132.) ‡ that he has adopted this identification. He has shown that the Hils-conglomerat and this clay are in Hanover distinctly superior to the Wealden (Wälder-thon); a fact of importance, coinciding with our own sections in proving that the Neocomian (or that part of it at least which is identical with the *Hils* deposits), cannot be contemporaneous with the Wealden, *upon* which it is found to repose.

The Hanoverian series is farther interesting to the English geologist, as demonstrating that the fresh-water deposits contemporaneous with our Wealden were not quite of such limited extent as has been supposed.§

No limestone like that of Kent has been found in Hanover; and

* It may be worth while to ascertain by exact search in the department of the Aube, whether traces of the Wealden itself do not exist there below the Neocomian strata of M. Leymerie. It is stated by M. Dufresnoy that he had seen such indications near Angoulême; and they exist, according to M. Passy, in the vicinity of Beauvais, Pays de Bray. See Bulletin de la Soc. Geol. de France; and Geol. Trans. vol. iv. p. 327.

† Mr. Austen has recently expressed the same view respecting this clay, on different and independent evidence. — See Proceedings of Geol. Soc. June, 1843, vol. iv. p. 196.; but Professor Agassiz had previously assigned its correct place to the Speeton clay, having stated its identity with the *Neocomian* clay of Neufchâtel, at a meeting of the Geol. Soc. of France, April 16. 1838. Bulletin, &c. ix. p. 262.

‡ The work of M. Roemer here referred to, "*Die Versteinerungen des nord-deutschen Kreide Gebirges*," was published in Hanover in 1841.

§ In the work of M. Geinitz, on the Fossils of the Saxon Cretaceous Hills, (Dresden, 1839 to 1842,) it is intimated that the Wealden occurs below the cretaceous series in that country.

M. Rømer considers the "yellow (Neocomian) limestone" as inferior to his Hils-conglomerate and Hils-clay, which, however, contain, like our Atherfield strata, many of the characteristic Neocomian fossils.

§. The Neocomian of the Crimea was described in the Letters of M. Dubois, published in 1837 in the Bulletin of the French Geological Society*: the writer having been the first, as he states, to discover an analogue of the Neufchâtel Neocomian in the Crimea, which presents fossil species so much alike in form that it was impossible to distinguish them; the general aspect of the beds also being perfectly the same. The lower bed, however, (which M. Dubois calls *Neocomien* in his section,) may well be a calciferous expansion of the lowest beds at Atherfield. It is characterised by the *Terebratula biplicata* and *Exogyra Couloni* (which Professor Edw. Forbes considers as identical with *E. lævigata* of Sowerby), two of the most characteristic shells of the lowest limestone of Kent. Above this, and next in succession, are about 40 feet of schist, which may represent our gault; and between this and the "étage supérieur de la craie," is a series like the Upper Green Sand.

Beyond the Caucasus another Neocomian deposit exists at Koutaïs and at Kèreïte, with fossils including small *Nerinaea* and *Diceras* like those of Mont Venteux, Grenoble, but accompanied by many other of the more usual Neocomian species.

It is not surprising that a statement by a naturalist and traveller of such authority as M. Dubois, should have fixed the attention of the French Geologists, who had previously been occupied with the Terrain Neocomien. Nor was it unnatural that M. Dubois himself, in recurring to his native country, should have looked no farther; even if he had been acquainted with the English works concerning the beds below the Chalk, where he might have found other evidence of a striking affinity to what he has described.

§. On a general view of the strata beneath the Chalk as they exist upon our own coast, it is evident, that, notwithstanding the local variations, the Lower Green Sand has a definite and distinct character; extending throughout from the Wealden to the Gault, and bounded naturally by those two groups, with their distinct and peculiar fossils: and it is apparent, also, that there is no natural connection between the Upper and the Lower Green Sand. The distribution of the fossils in the lower sands is very unequal; they are numerous at the lower part, rapidly diminish upwards, and (at present) seem to be nearly wanting at the top†; the same species, however, are carried through the whole, the upper fossils being a selection, as it were, from those below. It is in-

* Bulletin, vol. viii. p. 385 — 389.

† Among the fossils of these beds near Folkstone, where phosphate of lime occurs in detached masses, are the remains of an *Astacus*, a plicated *Terebratula*, stem-like concretions of *Siphonaria*, and fragments of an oyster or *Gryphæa*. (See Geol. Trans. vol. iv. pp. 117, 118.)

deed not improbable that this absence of fossils may be local, or apparent, arising only from imperfect search.*

It may be observed of all the supposed equivalents of the Neocomian beds, that while some species are very generally diffused, others (and apparently the greater number) are peculiar to each place. So that although some remarkable continental forms are wanting in this country, we have in return many which do not occur elsewhere. The recent examination of the Isle of Wight has brought to light several species new to the continental faunas as well as our own. †

§. There can now be no reasonable doubt that the *Terrain Neocomien* of Central France, illustrated by M. Leymerie, as well as that of Neufchâtel, represent the lower and middle portions of our sections at Hythe and in the Isle of Wight. We want, probably, many species of the Aube; — but we have long possessed a great number of the characteristic Neocomian forms, and are daily adding to the list. The great difference consists in the absence of calcareous strata below the clay of Atherfield — (the *Argiles Ostréennes* of M. Leymerie); and the general question seems to be reduced to this: — Whether the presence of a certain number of characteristic fossils in two distant places is sufficient to establish geological identity — where not only the species, and the numbers of the fossils, and the mineral composition of the strata is varied, but where one of the two objects compared is so very much superior in thickness and extent to the other, as the deposits of the south of Europe are said to be with respect to that of central France, — of England, — of northern Germany, — and even, it would seem, of Neufchâtel itself. I believe that Geologists generally will be in favour of the identification by fossils — even in this extreme case — and will be disposed to regard the greatest diversity of mass and composition as nothing more than *accidents* — so called perhaps because we are not able to account for them.

If, on the other hand, it be found that, in the south or elsewhere, the *lower* members of the so-called Neocomian (for the true Neocomian and the Lower Green Sand are unquestionably the same) become distinguished notably by fossils new in form and in great numbers, it would seem that the name of that portion of the deposit so distinguished ought to be changed; the upper strata remaining with the cretaceous groups, and the lower being regarded as something new and different from the Cretaceous system. Whether

* The place in the series of the Blackdown beds of Devonshire is still a subject of doubt. But if (which is not wholly improbable) they belong to the upper part of the lower green sand, the fossils in that division will then be nearly as abundant as they are in the lower members at Atherfield, &c. The siliceous casts are so remarkable, that if a similar deposit exists in many other parts of this country, it is unlikely that they should have remained unknown. In the upper part of the sands near Folkstone and Sandgate there are spongy siliceous concretions very like the Devonshire whetstone, but in which shells are very rare.

† *Ammonites asper* is one of the species generally diffused on the Continent, which has never yet been discovered here.

the new deposit thus supposed to exist shall be considered as the representative of our *Wealden* is still another question, which it is not necessary to enter into at present.

§. In the mean time, every Geologist who doubts the possibility of any part of our Lower Green Sand assuming the form of limestone, and, in that condition, acquiring great development and importance, will do well to examine the quarries of the Kentish Rag on the south-east of Maidstone*; where the stone which in other portions of this tract is concretionary, and irregularly distributed through masses of soft calcareous tuff, assumes the form of uniform and continuous strata of compact limestone, ranging horizontally through large spaces, and adapted, by its firmness and durability, to all the purposes of the architect and mason. In these same quarries, it is probable, abundant proofs of identity with the Neocomian beds will be found: and this within twenty miles of a tract where nearly the whole deposit is composed of sand.

The *Boughton Group*, like that of Hythe and Kent in general, may answer to the Upper Neocomian limestone; as the fullers' earth and other clays of Atherfield correspond to the blue marl of Neufchâtel. It is useless to press exact identification between such distant deposits to an extreme, since we constantly find diversity even in the adjoining quarries of a continuous country; while on the other hand, Geologists are frequently surprised by minute points of *empirical* resemblance in very distant places.

§. The author of this paper had long since stated the objections to which the name of *Lower Green Sand* is exposed †, but thought it expedient in 1835 to adopt that term, on the ground of its universal employment in England, and its very general reception on the Continent.‡ On this ground he still thinks that this name ought, for the present, to be retained. If hereafter a change be thought desirable, he conceives that the new denomination should be taken from the *Isle of Wight*, where this portion of the subcretaceous groups was first distinguished, and where the sections on the coast are remarkable for their distinctness; and if such a case should arise, he suggests the name of *Vectine* for the strata now called Lower Green Sand, from the ancient name of that island, — *Insula Vectis* of the Romans.

3. *On the Junction of the LOWER GREEN SAND and the WEALDEN, at the TESTON CUTTING.* By F. W. SIMMS, ESQ. F.G.S.

THE Author in this communication mentions that the beds resting on the Wealden in this locality (near Teston turnpike, on the

* Especially at Boughton.

† *Annals of Philosophy*, London, 1824.

‡ *Geol. Trans.* 2d Ser. iv. p. 105.

Maidstone junction of the South-Eastern Railway), seem to be identical with the marine clays found at Hythe and at Atherfield in the Isle of Wight. He adds, "There is also a bed of stone, not a continuous bed, but in concretionary masses, just above the junction, from which I obtained fossils, and which, I consider, represents the Atherfield rocks. This bed is also similar to the blocks taken from the cutting in the vicinity of Red Hill, near Reigate." He adds, that the same junction can be traced from the Teston Cutting in the direction of Maidstone, to near the Farley Cutting through the Kentish Rag. The junction of the Wealden and greensand clays is at the bottom of the valley, near the banks of the river Medway.

4. *On the Section between BLACK-GANG-CHINE and ATHERFIELD POINT.* By CAPT. L. L. B. IBBETSON, and PROF. EDW. FORBES, F.R.S.

THE accompanying Table exhibits the succession of strata presented in ascending order from the Wealden to the top of the Upper Green Sand in the Isle of Wight between Atherfield Point and St. Catherine's Down. The measurements of the upper portion were ascertained by trigonometrical survey, by Capt. Ibbetson, during the years 1833—38, those of the lower portion during the winter of 1842—3.

The following observations refer to that portion of the section which includes the Lower Green Sand strata, visited by Capt. Ibbetson and Prof. Forbes in March, 1844.

Between the Gault, as seen near Black-Gang-Chine, and the Wealden at Atherfield Point, there are sixty-three distinct strata, the total thickness of which is 843 feet.

§ 1. *Description of the Strata.*

The lowest of these is a brown clay 3 feet thick, the base of which, at the junction with the Wealden, abounds in remains of fish. Through this clay are scattered many fossils, none of which are peculiar to this lowest bed, but mostly such as run on through the fossiliferous clays of the Lower Green Sand. This is succeeded by a harder bed or rock of a sandy texture, 2 feet thick, characterised by the presence of numerous fossils, among which the most remarkable is the *Perna Mulleti*, peculiar to this bed.

The clays which succeed are fossiliferous at the lower part, but very slightly so in the middle, where they contain numerous crystals of sulphate of lime. The uppermost of these clay strata, called the *Lower Lobster-bed*, is an impure fullers' earth, abounding with fossils, the most characteristic of which are numerous remains of *Astacus* scattered here and there, and found in so perfect a state that no time could have elapsed between the death of the animal and its entombment in the strata, sufficient to permit decomposition to take place. These clays present a thickness of 99 feet.

The hard noduliferous bed which succeeds, termed the *Lower*

Crackers, is full of *Gervillia aviculoides* and other fossils, and a similar stratum immediately above (the *Upper Crackers*) abounds in fossils peculiar to itself; indeed it is in this bed that most of such of the species as are limited in their distribution, occur. The *Crackers* occupy a thickness of 18 feet.

A clay bed, 20 feet thick, having the properties of fullers' earth, and similar in appearance to that preceding the *Crackers*, succeeds: it is very fossiliferous, and, like the other, abounds in Crustacea, mostly of species identical with those in the *Lower Lobster Bed*. This is termed in the section the *Upper Lobster Bed*. *Ammonites* and several bivalves accompany these crustacea.

A dark sandy clay succeeds, and is very fossiliferous; the characters of the fossils do not for the most part differ from those in the lowest clays. It is 20 feet thick.

This is capped by a band of *Terebratulæ* (mostly *T. Gibbsii*) imbedded in the stratum of dark sand, 22 feet thick. The *Terebratulæ* are in immense abundance and accompanied by *Serpulæ*.

A series of beds containing zones of *Gryphæa sinuata* imbedded in dark sand succeed. The *Gryphæa* zones mostly alternate with rows of large nodules containing *Crioceras* and *Scaphites*. This assemblage of *Gryphæa* zones is interrupted in the centre by a bed of sandy clay, 34 feet thick, very fossiliferous, and in which a great many of the fossils of the lower clays reappear. These *Gryphæa* and *Crioceras* beds, with the included clays, have a thickness of 155 feet.

Thirty feet of dark sand, containing prolific zones of *Terebratulæ*, chiefly *T. biplicata*, succeed, and form the base of a new succession of *Gryphæa* bands imbedded in dark sand; but the *Crioceras* nodules are absent. Twenty-four feet is the extent of this uppermost series of *Gryphæa* zones.

Above this the beds become ferruginous, and are occasionally, though rarely, mixed with dark blue clay. Fossils in some parts are abundant, but mostly in the state of casts, and no new forms appear. A lignite bed occurs in the lower part of these ferruginous beds, the lignites being arranged in zones. There are also here and there rows of calcareous concretions, usually of an oblong shape, and mostly having a direction towards the S.E., like the lines of oblique bedding occasionally presented in this part of the series.

At the top of Black-Gang-Chine waterfall, a series of indurated ferruginous sand rocks alternating with dark sandy clays appear. The sand rocks are composed of quartz grains, and exhibit lines of oblique bedding. They contain no fossils.

At the uppermost part of the Lower Green Sand is a series of thin beds, alternately ferruginous and sand, lying immediately below the gault. Casts of a *Solarium* (species unknown), and of an *Ammonite*, were found in these bands.

§ 2. *Grouping of the Strata.*

The 63 strata enumerated may be grouped under three divisions, from their general mineral character.

A. The lower assemblage of clays, mostly fullers' earth, abounding in fossils, and in which the *Perna* sand-rock and the Cracker nodules are exceptional strata indicating temporary conditions.

B. The region of *Gryphæa sinuata* sands in which the *Terebratula* bands and upper clays are exceptional strata. This region may be subdivided into three portions, the two lower containing *Crioceras* nodules separated by the clay, and the upper containing no nodules. The noduliferous part of the series, and that which is free from the nodules, have each a zone of *Terebratula* for a base.

C. The region of ferruginous sands, which may itself be divided into two or three sections, the lowest of which is fossiliferous.

§ 3. *Chemical Peculiarities of the Beds.*

A chemical analysis of the composition of the several strata was next given; the principal results of which, affecting the distribution of the organic remains, are the following:—

The beds which are most fossiliferous are those containing most carbonate of lime. In the ferruginous beds, whether upper or lower, there are no traces of lime; but large quantities of peroxide of iron. This is true as well of the fossiliferous as the non-fossiliferous parts. The gault which caps the iron bands at Black-Gang-Chine contains but few fossils, and those occur rarely. On analysis it was found to exhibit no trace of carbonate of lime, but a little gypsum; whereas the fossiliferous gault of Folkstone and other places abounds in carbonate of lime.

§ 4. *Indications of Conditions under which these Beds were deposited.*

At the close of the deposition of the Wealden, there appears to have been a sudden depression of the bed of the great freshwater estuary, and an influx of the sea. The first effect of such an influx would be the destruction of the animals in the estuary not adapted for living in salt water; hence we find a total destruction of the Wealden animals, the remains of which accumulate towards the point of the junction of that formation with the Lower Green Sand; a fact which indicates the nature of the change. Even the *Cerithium*, although belonging to a genus many species of which are capable of living in the depths of the sea, was destroyed—notwithstanding that its appearance, only in the uppermost beds of the Wealden, indicates that its presence there was due to the commencement of the very state of things which eventually destroyed it. That the depression was of some extent, though not, perhaps, of very many fathoms, is indicated by the nature of the animals which lived in the first-formed sea-bed, and which, when they died, were often imbedded in the fine and, probably, fast depositing mud, in the vertical position which it is the habit of the animals of such genera as *Pinna* and *Panopæa* to assume when alive. After this, a temporary change followed, when an influx of sand, mingling with the calcareous mud, caused a state of sea-bottom peculiarly favourable to the presence of animal life. In this way were called

into existence a multitude of species which were added to those which had appeared before them. This was, in fact, such a state of sea-bottom as is now presented by great shell banks; but it does not seem to have lasted long, and new depositions of mud appear to have extinguished some forms, whilst others suffered by the change only in the diminution of their numbers. In the midst of this muddy epoch, a temporary and peculiar condition of sea-bottom, forming what are now called the Crackers, called forth the presence of numerous mollusca, at first of various species of the genus *Gervillia*, and afterwards of *Auricula*, *Cerithium*, *Dentalium*, and other univalves, which appear to have enjoyed but a brief existence (as species) in this locality, since similar conditions were never afterwards repeated. The greater number of the Gastropodous mollusca of the English Lower Green Sand are found within this very limited range. At the close of the deposition of this great mass of clay there was for a time a great multiplication of the individuals of certain *Brachiopoda* which had commenced their existence in the lowest beds. Thus *Terebratulæ Gibsi* suddenly appears in immense abundance, covering the bottom of the sea, and predominating over the animals among which it had previously been but thinly scattered.

This lowest zone of *Terebratulæ* marks the commencement of a new state of sea-bottom where sands predominated over the clays, each interval of deposition being usually marked by the presence of a layer of *Gryphæa sinuata*, the period of rest being almost always sufficient to enable the *Gryphæa* to attain its full growth. Other bivalves are found with it, but in comparatively small numbers, and not such as are of gregarious habits. During the whole of this period enormous *Cephalopoda* including species of *Crioceras* and *Scaphites* frequented these seas, and when dead formed the nuclei round which calcareous and sandy matter collected and formed nodules. The death of these animals seems to have been connected with the periodical charging of the sea with sediment; hence we find them usually alternating with the zones of *Gryphæa*, and forming irregular bands in the intervening sedimentary deposits.

In the midst of this epoch of *Gryphæa*, there is a sudden re-appearance of the muddy deposits, during the predominance of which those animals adapted for such a sea-bottom, and which had survived the cessation of the deposition of the fullers' earth, again multiplied, but the species which had become extinguished were not replaced by representative forms. This, however, did not last long, the sand again predominating with its zones of *Gryphæa* and lines of *Crioceras* nodules.

A temporary multiplication of *Terebratulæ sella* suddenly marks a change in the zoological conditions — for the *Cephalopoda* disappear, although the zones of *Gryphæa*, which animal does not appear to have been affected by the change, (probably a change in the depth of the sea,) go on as before, there being, however, no alternating lines of nodules. It would seem that the sea began to

shallow, probably from elevation of the sea-bottom, until at last the *Gryphæa* itself disappears, the bands exhibit traces of the influence of currents, and become more gravelly; lignites, indicating a shallow sea, become common, form belts in the ferruginous sand, and in one place a bed in the wavy blue sand, at a time when much iron was deposited. The deposition of the peroxide of iron appears to have been connected with the disappearance of the majority of mollusca, though *Trigonia*, *Thetis*, and *Venus* occasionally occur in considerable numbers. In the uppermost strata scarcely any animal remains are found, and every thing appears to indicate a shallow and barren sea, previous to a new state of things, when a fresh series of clays (forming the Gault) being deposited, the majority of the animal forms which characterise the clays of the Lower Green Sand disappear, and are replaced by distinct species, representative in time.

§ *Bearing of these Observations on the Neocomian Question.*

These statements regarding the distribution of organic remains and indications of mineral conditions, presented by the Atherfield section, lead to a few considerations which bear importantly on the question which has been agitated respecting the separation of the lower part of the Lower Green Sand as a separate bed under the name of "*Neocomien*."

1st. It would appear that there is but one system of organic remains throughout the series of beds, entitled Lower Green Sand, in this locality, and that whenever similar conditions are repeated, the same species reappear.

2d. Throughout the series of beds examined, we find that when a species is extinguished by a change of mineral conditions, it is not replaced by a representative species.

3d. That the influences which determine the distribution of species throughout are mineral and local, and that these mineral—in a great measure, chemical—conditions enable us to divide the strata into groups, which groups, being from their very nature local, cannot be regarded as other than artificial, and have no claim to be numbered as subdivisions in time of the great series of cretaceous deposits.

A change of mineral conditions may determine the absence of certain species; but, unless when, under a repetition of similar mineral conditions, such species are replaced by representative species, or the general assemblage of species is replaced by representative and distinct forms, the change cannot be considered as indicating a great sectional division.

It appears to us, therefore, that the evidence of the Atherfield section maintains the unity of the Lower Green Sand; and that the accumulation of clays at its base can be regarded only as a local phenomenon.

Thickness and Description of Strata.

[GAULT, WITH FOSSILS.]

No.		Thickness in feet.
64.	Iron band, fragments of fossils - - - - -	1
63.	Dark sand - - - - -	2
62.	Iron band - - - - -	1
61.	Dark sand - - - - -	2
60.	Iron band - - - - -	1
59.	Dark sand - - - - -	2
58.	Iron band - - - - -	1
57.	Iron clay and sand - - - - -	12
56.	At the top, white sand ; at the bottom, black sand and clay -	11
55.	Iron at the top, and sand - - - - -	3
54.	Iron at the top, and dark yellow sand - - - - -	4
53.	Yellow sand and clay - - - - -	6
52.	Blue clay - - - - -	2
51.	Yellow and white sand, very quartzose - - - - -	15
50.	Above, white sand, tolerably solid at the top, clay and sand in the middle, and white sand at the bottom - - - - -	19
49.	Black clay (perhaps lignite) with brown sand in thin laminae, tolerably even, but in some parts wavy - - - - -	17
48.	Yellow sand and blue clay, thinly laminated in some parts, wavy at the bottom, the sand white - - - - -	31
47.	A second white sand, tolerably solid - - - - -	13
(No. 31. crops out on the shore, a little to the west of Blackgang Chine.)		
46.	Blue sand and some clay - - - - -	32
45.	A line of nodules at the top, and blue sand and some clay below -	33
44.	Third white sand, with tolerably solid yellow at the bottom. This stratum runs up from Rocken End - - - - -	22
43.	Three sorts of black clay and sand - - - - -	40
42.	Iron, fossiliferous, top of Blackgang-Chine Waterfall - - - - -	1
(No. 24, (the Terebratula zone) crops out on the shore.)		
41.	Sand and clay varying from brown to black - - - - -	4
40.	Iron, fossiliferous - - - - -	1
39.	White sand, tolerably solid, yellow on the surface ; near the top there are laminae of pebbles ; the bottom of it is in thin laminae, divided by blue sand and clay - - - - -	11
38.	Iron, fossiliferous - - - - -	1
37.	White sand - - - - -	10
36.	Blue clay and sand, the blue very conspicuous - - - - -	1
35.	Iron at the top, with fossils ; dark sand below - - - - -	26
(Nos. 22. and 23. nodules crop out on the shore.)		
34.	Iron at the top, fossiliferous, and dark sand below - - - - -	18
33.	Iron, fossiliferous, and grey sand below, much used for making mortar. Bottom of Blackgang - - - - -	28
(No. 21. nodules crop out on the shore.)		
32.	Iron, fossiliferous, and white sand below - - - - -	9
31.	Thin very wavy laminae of black clay (or lignite) full of pyrites, with a layer of spongiform nodules near the bottom - - - - -	25
(No. 20. nodules crop out on the shore.)		
30.	Iron at the top, fossiliferous, with dark sand - - - - -	2

Thickness and Description of Strata.

No.		Thickness in feet.
29.	Iron, fossiliferous, with dark sand. Above the boat-houses, Ladder Chine - - - - -	3
	(No. 19a crops out on the shore.)	
28.	<i>Gryphæa</i> at the top, with dark sand - - - - -	8
27.	<i>Gryphæa</i> at the top, with dark sand - - - - -	3
26.	<i>Gryphæa</i> at the top, with dark sand containing <i>Terebratulæ</i> , <i>Echini</i> , &c. &c. &c. - - - - -	4
25.	<i>Gryphæa</i> at the top, with dark sand - - - - -	9
	(Nos. 15, 16, 17, 18, 19. <i>Gryphæa</i> and <i>Crioceras</i> nodules crop out on the shore.)	
24.	<i>Terebratulæ</i> at the top, with dark sand - - - - -	30
23.	Nodules containing <i>Crioceratites</i> , a layer of <i>Gryphæa</i> under them, with dark sand - - - - -	7
	(No. 14. or <i>Scaphite</i> nodules crop out on the shore.)	
22.	<i>Crioceras</i> nodules; a zone of <i>Gryphæa</i> , with dark sand - - - - -	13
21.	<i>Crioceras</i> nodules, a zone of <i>Gryphæa</i> , with dark sand containing <i>Gryphæa</i> irregularly placed - - - - -	3
20.	<i>Crioceras</i> nodules with <i>Ammonites</i> - - - - -	26
19a	At the top black sand and clay, a zone of <i>Gryphæa</i> in the centre, with clay under, very fossiliferous - - - - -	34
19.	} <i>Crioceras</i> nodules with zones of <i>Gryphæa</i> , dark sand between them	38
18.		
17.		
16.		
15.		
	(Nos. 13. 12. 11. 10. crop out on the shore below these zones.)	
14.	Nodules containing <i>Scaphites</i> ; <i>Gryphæa</i> zone under; <i>Ostrea cari-</i> <i>nata</i> , &c. at the top of dark sand; at the bottom layers of <i>Serpulæ</i> , <i>Terebratulæ</i> , &c. &c. - - - - -	16
	(No. 8 crops out on the shore below.)	
13.	Zone of <i>Gryphæa</i> ; below red sand and clay, full of <i>Gryphæa</i> , <i>Ostreæ</i> , <i>Terebratulæ</i> , <i>Pectens</i> , <i>Serpulæ</i> , &c. &c. &c. very fossiliferous, and in some places divided into four zones of <i>Gryphæa</i> - - - - -	22
	(No. 7. crops out on the shore.)	
12.	Layer of <i>Terebratulæ</i> , dark sand at the top, and a layer of small no- dules and yellow sand at the bottom - - - - -	22
11.	Dark clay, red at the top, and very fossiliferous - - - - -	20
	(No. 6. crops out on the shore.)	
10.	Upper lobster bed, dark sand at the top, fullers' earth in the middle, and sand at the bottom, very fossiliferous - - - - -	45
9.	Upper Crackers; nodules at the top, clay and sand, very fossiliferous	6
8.	Lower Crackers; nodules at the top, full of <i>Gervilliæ</i> , &c. &c., with brown sand and clay, fossiliferous - - - - -	12
	(No. 4., or <i>Perna Mulleti</i> bed, crops out on the shore.)	
7.	Lower lobster bed, fullers' earth, very fossiliferous - - - - -	29
6.	The best fullers' earth with clay at the bottom, some fossils, but not very plentiful, and in some parts full of large crystals of sulphate of lime - - - - -	64
5.	Layer of small nodules, clay at the bottom containing fossils - - - - -	6

SHOWING THE (THE SPOT) IN THE ISLE OF WIGHT.
RBES.

The object of this table is to show the range in the lower beds of that formation, and that of the Cretaceous Series.

NOTE. — Positions above or below the Lower Green Sand.

3. Lowest Clay.	Range.	14. Middle Clay.	Range.	15—16. Middle Gryphæa Sands.	Range.	19 a. Upper Clay.	Range.
Panopæa mandibula -	3—U.G.S ²	Cypricardia undulata.	14	Crioceras Bowerbankii.	15—29	Cardium ? imbricatum.	19a
Panopæa plicata -	3—U.G.S ²	Nucula spatulata	14	Scaphites giganteus.	15—29	Anomia radiata.	19a
Hemicardium Austeni -	3—15 ²	Gervillia solenoides.	14—56	Nautilus radiatus	15—19	Arca securis	19a
Venus ? parva -	3—57, —29	Lima elongata -	14—Glt.			Belemnites Sp. -	19a
Venus ? fenestrata -	3	Spatangus retusus.	14—29				
Arca Raulini -	3—19a ¹²						
Nucula (scapha) -	3—29						
Trigonia caudata -	3—U.G. ¹						
Perna Mulleti -	3—4						
Gervillia aviculoides	(Ool.) 3—U.G. ¹						
Ostrea carinata -	3—Ch.M.						
Pecten 5-costatus -	3—Ch.						
Pecten obliquus -	3—U.G.						
Pecten orbicularis -	3—U.G.						
Rostellaria Parkinsoni	3—Glt.						
Rostellaria bicarinata -	3—14						

TABLE

SHOWING THE DISTRIBUTION OF LOWER GREEN SAND FOSSILS (AS NOTED ON THE SPOT) IN THE ISLE OF WIGHT.

BY CAPTAIN BOSCAWEN IBBETSON AND PROFESSOR E. FORBES.

The object of this table is to show that the majority of species composing the Lower Green Sand Fauna, as observed in the Isle of Wight, commence their range in the lower beds of that formation, and that the species assembled in the lowest beds include many common to the Lower Green Sand and other divisions of the Cretaceous Series.

NOTE. — The Figures refer to the Beds as numbered in the Table of Strata; the Roman Letters in the second columns to Formations above or below the Lower Green Sand. Names of Species within brackets have been applied since the Paper was read.

In the beds above 19a no species were observed to commence their range.

[illegible]

Thickness and Description of Strata.

No.		Thickness in feet.
4.	<i>Perna Mulleti</i> bed, with numerous <i>Gryphææ</i> , <i>Ostreæ</i> , &c. &c. very fossiliferous - - - - -	3
3.	Clay, very fossiliferous, containing layers of fish-bones, teeth, &c. but regular - - - - -	3

(WEALDEN.)

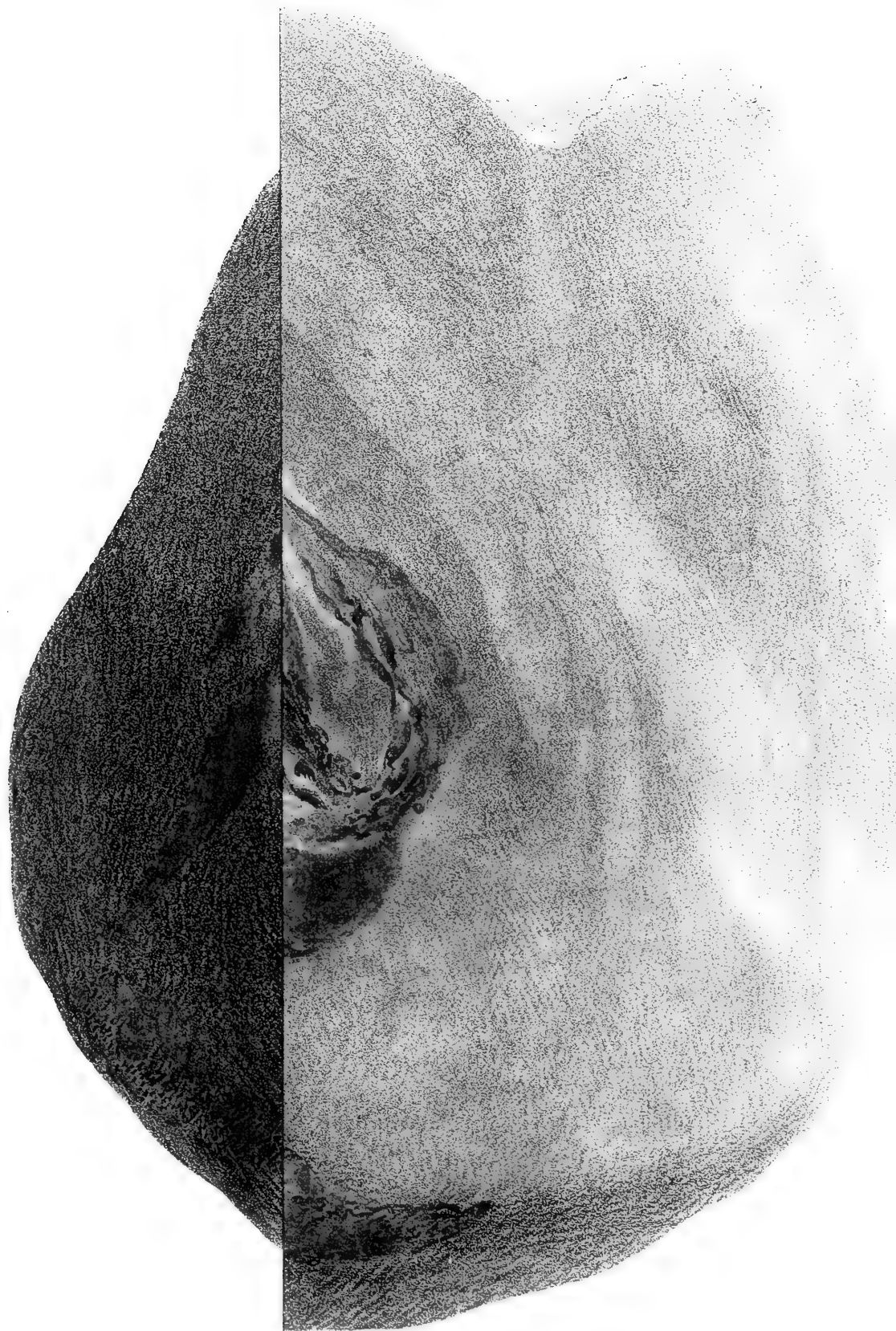
In the accompanying Table are given the ranges of such of the fossils of the above strata as were collected and noted by the authors on the spot.

5. *Description of the Mouth of a HYBODUS found by Mr. BOSCAWEN IBBETSON in the ISLE OF WIGHT.* By Sir PHILIP MALPAS DE GREY EGERTON, Bart. M.P. F.R.S. F.G.S.

THE present memoir is the result of the examination of an Ichthyolite discovered by Mr. Boscawen Ibbetson in the Isle of Wight, near the junction of the Lower Green Sand with the Wealden, and sent to me in the hopes that it might tend to show to which of the two formations this bed should be assigned. The evidence it affords on this question is neither direct nor conclusive, inasmuch as it is an undescribed species, and consequently any deductions beyond those based upon general affinities would be unwarrantable. In another point of view, however, this specimen is of high scientific value, as it sets at rest the long-mooted questions of the relative characters of the upper and lower teeth, and their general contour in the individuals composing the genus *Hybodus* so extensively occurring in the secondary strata. Mr. Ibbetson has had the rare fortune to bring to light the entire mouth of a fish of this genus. The left side is slightly crushed, but the other retains its natural form, and the greater portion of the teeth in both the upper and the lower jaw. The former measures 10 inches, and appears to have carried twenty-four teeth in the front series; the latter measures $7\frac{1}{2}$ inches, and has nineteen teeth in series, one on the symphysis and nine on either side. Two rows of succession teeth are traceable behind the front series. The mouth is slightly open, and when seen in profile is more arcuate than in the recent sharks. The upper jaw has a broad notch for the reception of the thickened symphysis of the lower mandible. The teeth have a central cusp, rather hooked, and two secondary cusps on either side; the enamel is strongly plicated; the teeth only recently brought into use have the plicæ extending to the apex. The bases are wide, and have the rugose character so generally found in this genus. The lateral teeth present the same characters as the more central ones, but are rather smaller near the angle of the jaw,

The central teeth, also, are rather smaller than those immediately flanking them. The teeth of the upper jaw are precisely similar to those in the lower. In neither do we find any material increase of obliquity in the cusps as they recede from the centre. The cartilaginous alæ of the mouth are distinctly traceable; they increase in width rapidly from the symphysis of the lower jaw, and attain their maximum expanse at the angle of the mouth. Behind these are some traces of the hyoid arch. It is probable from the appearance of the matrix which envelopes it, that with a little careful cleaning a considerable portion of the head might be disclosed. In its present condition, the only part of the cranial cartilages to be distinguished is a section of the prosencephalic cavity.

The geological inferences afforded by this specimen are briefly told. The species is new. The genus is undoubtedly *Hybodus*. This genus attains its maximum expansion in the Oolitic series, but it ranges from the Muschelkalk to the Chalk inclusive. The only evidence of its occurrence in the latter formation is a fragment of an *Ichthyodorulite* in the Mantell collection. The teeth have not yet been found in any strata more recent than the Wealden. As far therefore as the evidence goes, it leads to the supposition that a bed containing teeth of the genus *Hybodus* is most likely to be of an age anterior to the cretaceous system. In a zoological point of view, this specimen is of more importance, inasmuch as it fully corroborates the views advanced by Agassiz, "that most probably the *Hybodonts* differed little from the recent sharks in general aspect." It also authenticates the numerous species established by that distinguished naturalist from the characters of isolated teeth. We find in many of the recent sharks, in *Carcharias* for example, the discrepancy between the teeth of the upper and lower jaw so great, that it would be considered quite warrantable to describe them, if found detached, as different species. It was from a just appreciation of these difficulties that Agassiz has always professed his names and characters of the placoid teeth to be descriptive of specimens, and to be considered provisional as regards specific arrangement, until evidence should be found authorising or annulling the continuance of the titles as applicable to species. Mr. Ibbetson's specimen shows that in the genus *Hybodus* there was no difference between the teeth of the upper and lower jaw, and less variation, according to position, than in the recent sharks; consequently the descriptive characters given in the *Poissons Fossiles* will hold good as specific distinctions. The *Hybodonts*, then, of the secondary strata differed only from the sharks of the recent period in those modifications which adapted them to the circumstances under which they existed. The form of the mouth was nearly similar; from this we may argue a similarity of shape and an analogous arrangement of the fins to enable them to seize their prey. If they subsisted upon fish, which is most probable from the form of the teeth, we find in the denser structure and hard enamel coating of these organs, provisions to enable them to grapple with the Ganoid fishes of that period; while in the powerful fin bones with which they were armed, we





Hybodus Basanites. Egerton



see weapons of defence against the aggressions of the Piscivorous Saurians with which they were destined to coexist. I propose to name this species *Hybodus basanus*.*

6. Extracts were read from letters of M. Dubois de Montpereux to Mr. L. L. Boscawen Ibbetson, on the comparison of the Neocomian beds of the Caucasus and the Crimea with those of Neufchâtel, and from Professor Agassiz to Mr. Ibbetson, on the age of the Neocomian beds of Neufchâtel.

MAY 15th, 1844.

W. J. Blake, Esq., of Danesbury, was elected a Fellow of this Society.

The following communications were made : —

1. *On some CRUSTACEOUS REMAINS in CARBONIFEROUS ROCKS.*
By W. ICK, Esq., F.G.S.

THIS communication accompanied two electrotype casts of the specimens alluded to. The one was found in the white ironstone measures at Ridgeacre Colliery, and the author states,—“ I at first thought it might be the head and carapace of a new species of *Eryon* except that the known species from the Solenhofen slate are much more deeply notched on the edges of the carapace, and the apparently spinous prolongation of the head and some other details do not agree. The white ironstone in which it was found is a bed in the lower part of the field below what is called the New Mine coal. It is the bed in which the finest remains of *Megalichthys* have been found.”

“ The other fossil is in an ironstone nodule. The form is not so well defined as in the first, and I dare not venture to guess to what it may be referred.”

2. *On the probable Age and Origin of a Bed of PLUMBAGO and ANTHRACITE occurring in mica-schist near Worcester, Massachusetts.* By C. LYELL, Esq., M.A., F.R.S., F.G.S., &c.

A BED of plumbago and impure anthracite described by Professor Hitchcock in his “ Geology of Massachusetts ” is found interstratified with mica-schist near Worcester, forty-five miles due west of Boston. It is about two feet in thickness, and has been made use of both as fuel and in the manufacture of lead-pencils. It is much mixed up with the associated rock, has the touch and somewhat of the lustre of plumbago, and gives a streak on paper. It is occasionally iridescent like coal, contains pyrites, which is also found in the associated clay slate and garnetiferous mica-schist,

* The accompanying plate exhibits the appearance of the fossil embedded in the rock, and partially cleared.

both of which are impregnated with carbonaceous matter. This plumbaginous rock presents numerous polished surfaces or slickensides, on some of which are delicate parallel striæ, which reminded me so strongly of the finely striated leaves common in coal, that I had first supposed them to be of the same nature; and was thus induced to search very diligently, but in vain, for vegetable impressions. In the old mine of plumbaginous anthracite about two miles to the north-east of Worcester, the accompanying clay-slate and mica-schist, (the latter containing garnets and veins of asbestos), dip towards the north at an angle of between 30 and 40 degrees, and a railway cutting east of Worcester, and to the south of the old mine above mentioned, has finely exposed to view the mica-slate and clay-slate with some layers of quartz inclosing a bed of similar plumbaginous anthracite; some of which has the iridescence of peacock coal. Professor Hitchcock has traced this group of strata in a north-easterly direction 50 miles, to the Merrimac river, and the beds are continued with the same strike, in a south-westerly direction, for many miles. In their course they exhibit a great variety of crystalline strata, and the mica-slate sometimes alternates with gneiss.

The schists including plumbago, at Worcester, as above mentioned, are separated from the anthracite occurring on the borders of Rhode Island and Massachusetts, by a district of gneiss and hornblende slate about thirty miles wide. The anthracite of those slates is impure and earthy, but has been worked for coal at Wrentham, Cumberland, Mansfield, and other places, where, in the accompanying carbonaceous and pyritiferous slates, I collected numerous impressions of the most common coal plants, such as *Pecopteris plumosa*, *Neuropteris flexuosa*, *Sphenophyllum*, *Calamites*, &c. This earthy anthracitic coal, as well as the accompanying slates, contain pyrites, as at Worcester; and the anthracite exhibits the same glazed surfaces and slickensides; but it does not soil the finger like that of Worcester, and its specific gravity has been shown by Dr. Jackson and Professor Hitchcock to be less than that of Worcester, but greater than that of the anthracite of Pennsylvania. There are layers and veins of quartz in the slates and micaceous sandstones forming the roof of this anthracite, affording another point of analogy between this series and the quartziferous rocks at Worcester. I have also seen numerous specimens from the anthracite and bituminous slate of the neighbouring district of Mansfield, in which the usual coal plants were imbedded; but the slate was more crystalline. I was presented by Professor Hitchcock with a specimen of distinct mica slate from this neighbourhood, in which rounded nodules of granite and quartz rock are included; and in the contiguous parts of Rhode Island a conglomerate belonging to what has been called the greywacké formation has been observed by Dr. C. T. Jackson (Survey of Rhode Island, p. 70.) to pass downwards into mica slate. The rocks of the coal measures now under consideration are accompanied by a red sandstone, which I examined at Attleborough, a few miles from Wrentham before mentioned. There is a con-

glomerate subordinate to it, and it may, with all probability, be referred to the old red sandstone which occurs beneath the coal in Pennsylvania; although, in the absence of fossils, the disturbed state of the strata, and the frequent concealment of their outcroppings by a thick covering of drift, it is usually difficult to determine the exact order of succession. It is, however, important to observe that the whole of this series, which Professor Hitchcock now inclines to refer to the coal and old red sandstone, was formerly called greywacké, and styled the transition formation, in consequence of the semi-metamorphic condition of several of the rocks. Their conversion into crystalline strata, in the immediate neighbourhood of masses of granite and syenite, is often complete. But besides this kind of alteration, resembling the effect of dykes and veins of intrusive igneous rocks, there is evidence here, as in the Alps of the Canton of Berne and elsewhere, of a more extensive and general change by chemical or plutonic action, affecting, with greater or less degrees of intensity, dense masses of stratified rocks.

Although many impressions of plants have been found in this anthracite formation, on the southern borders of Massachusetts and Rhode Island no traces of shells or corals have been discovered. In like manner we find an absence of all fossils except vegetable remains, in the anthracite coal district of Pennsylvania, and no fossils of any kind in the subjacent conglomerates and red sandstones.

The strata of conglomerate at Brooklyn, near Boston, and the greywacké slates and sandstones of that neighbourhood, some of which pass into metamorphic rocks, and in which no plants or other organic remains have as yet been found, are doubtless referable to the same carboniferous and Devonian formations as those above described.

After traversing this region in several directions, it appeared to me very probable that the stratified rocks, containing the plumbaginous anthracite of Worcester, consisted originally of similar sedimentary strata, which have been so altered by heat and other plutonic causes as to assume a crystalline and metamorphic texture, by which the grits and shales of the coal have been turned into quartzite, clay-slate, and mica-schist, and the anthracite into that state of carbon which is called plumbago or graphite.

The progressive debituminisation of the coal of the United States, as we proceed from Pittsburgh to the eastern and more disturbed axes of the Alleghany mountains, as pointed out by Professor H. D. Rogers, lend support to this conjecture.* In the Rhode Island anthracite, which is less combustible than that of Potsville, Pennsylvania, the change seems to have been carried farther; the volatile ingredients of the original coal having been still more completely expelled. In the impure plumbago of Worcester, we may have the last step in the series of transmutation, where only 3 per cent. of gaseous matter remains, where all traces of fossil plants

* See Appendix.

and vegetable structure have been obliterated, and where the lithological character of the accompanying sedimentary rocks has been entirely altered. I may remark that the Silurian and Devonian formations, which are so largely developed in the United States, yield no beds of coal or anthracite which could by metamorphosis be supposed to become turned into such a carbonaceous stratum as that of Worcester.

I shall conclude by observing that the difference of strike between the mica-schist containing plumbago at Worcester, and the nearest carboniferous rocks of Rhode Island and Massachusetts, affords no argument against the theory of both having belonged originally to the same group of sedimentary strata. In New England, and in Nova Scotia, the coal-measures frequently deviate widely from the same strike in continuous districts, and the direction of continuous anticlinal axes in the Alleghany mountains, composed throughout of similar silurian and carboniferous rocks, has been shown by Professors W. B. and H. D. Rogers, to vary more than 40° in different sections of that chain.

APPENDIX. — *Analysis of Specimens of BITUMINOUS and ANTHRACITIC COAL of the UNITED STATES, and of the PLUMBAGINOUS ANTHRACITE alluded to in the foregoing Paper.*

In the Transactions of the Association of American Geologists, 1840-42, p. 470., Professor H. D. Rogers traces the gradation in the proportion of volatile matter in the coal, as we cross the Appalachian basin from the S. E. towards the N. W. In the most southeasterly basins, where the coal is a genuine anthracite, he states that the quantity of gaseous matter, chiefly hydrogen, varies from 6 to 14 per cent., as, for example, in the anthracite coal fields of Pennsylvania.

Secondly, further towards the N. W., in the Alleghany mountain of Pennsylvania, and the Potomac basin and others in Virginia, the proportion of volatile matter varies from 16 to 22 per cent.

Thirdly, westward of the Appalachian mountains, in the wide coal-field watered by the Ohio river and its tributary, the amount of volatile matter is from 30 to 40, and even 50 per cent. With a view of testing these results, I submitted to my friend Dr. J. Percy, of Birmingham, for examination, specimens of coal, first, from the Pennsylvanian anthracite of Lehigh and Mauch Chunk, in which the proportion of gaseous matter, (hydrogen, oxygen, and nitrogen) proved to be about 5 per cent. ; secondly, from Frostburgh in Maryland, a part of the Appalachian mountains further west, where the strata have only undergone a moderate degree of disturbance. In this coal, the proportion of volatile matter to the carbon and ash was found to be about $9\frac{1}{2}$ per cent. ; and, thirdly, in the horizontal and bituminous coal of Pomeroy, on the Ohio, the proportion of gaseous matter was determined to be about 19 per cent.

The theory of Professor Rogers is borne out by these analyses, but, as the chemical results are exceedingly different, the proportion of volatile matter being only half that cited by the American geologist, I think it right to append a letter which I have received from Dr. Percy, in order to show the details of his manipulations, and the pains bestowed by him on an analysis which, in the case of anthracite, is exceedingly difficult.

Letter from John Percy, M. D. to C. Lyell, Esq.

Birmingham, Feb. 17. 1845.

My dear Sir,

I have now much pleasure in transmitting to you, in a complete form, the analyses of the specimens of coal which you sent me. The ultimate analysis of coal requires considerable care, as it is difficult, by the ordinary method of combustion with an oxidising body, to effect completely the oxidation of all the carbon. In every instance I have used chromate of lead as the oxidising body, and have employed a degree of heat sufficient partially to melt the Bohemian-glass combustion tube, although defended by inclosing it in thin sheet copper. I have been particularly careful not only to mix, but to *triturate*, the coal powder and the chromate of lead intimately together. The coal powder has been dried in the oil-bath at a temperature ranging between 110° and 120° Centig. The analysis of coal consists of three parts, viz.

1. Of the determination of the carbon and hydrogen.
2. Of the determination of the nitrogen.
3. Of the determination of the ash.

The oxygen, of course, is found by deducting the sum of these from the weight of coal employed in analysis. As I have already stated, the carbon and hydrogen were found in the usual way by burning with chromate of lead, as in an ordinary organic analysis. The nitrogen was ascertained by Will's method, which consists in heating the coal with the mixture of soda-lime in a combustion tube; all the nitrogen is evolved in the form of ammonia, which is retained in the receiver, containing hydrochloric acid; the hydrochlorate of ammonia thus formed is converted into ammonio-chloride of platinum, from which the quantity of nitrogen is estimated. Lastly, the ash was found by incinerating in a platinum crucible until every speck of carbonaceous matter had disappeared.

I shall now proceed to give you all the data obtained by analysis:—

1. POMEROY COAL, OHIO. Colour of the powder, deep snuff-brown.

1st Analysis.

4·878 grs. gave

Water, 2·46 = Hydrogen, 0·273, or 5·59 per 100.
Carbonic Acid, 13·74 = Carbon, 3·747, or 76·81 do.

2nd Analysis.

5·686 grs. gave

Water, 2·96 = Hydrogen, 0·328, or 5·76 per 100.
Carbonic Acid, 15·97 = Carbon, 4·355, or 76·59 do.

Nitrogen Analysis.

6·90 grs. gave

Metallic Platinum, 0·836 = Nitrogen, 0·118, or 1·71 per 100.

Incineration.

6.44 grs. gave of Ash, 0.28, or 4.34 per 100.
 2.26 grs. do. 0.11, or 4.86 do.

Mean - - - 4.60 do.

2. MAUCH CHUNK, or PENNSYLVANIAN ANTHRACITE. Lustre somewhat glistening; powder much blacker than that of the preceding variety.

1st Analysis.

6.92 grs. gave

Water, 1.50 = Hydrogen, 0.166, or 2.398 per 100.
 Carbonic Acid, 21.44 = Carbon, 5.847, or 84.49 do.

2d Analysis.

6.02 grs. gave

Water, 1.33 = Hydrogen, 0.147, or 2.441 per 100.
 Carbonic Acid, 18.75 = Carbon, 5.113, or 84.93 do.

3d Analysis.

6.127 grs. gave

Water, 1.41 = Hydrogen, 0.156, or 2.546 per 100.
 Carbonic Acid, 19.11 = Carbon, 5.211, or 85.04 do.

Nitrogen Analysis.

I heated some of the coal on a test-tube with soda-lime. Red litmus paper was immediately turned blue; and, on holding the stopper of the hydrochloric acid bottle over the tube, dense white fumes appeared. The coal, therefore, contained nitrogen.

7.18 grs. gave

Metallic Platinum, 0.616 = Nitrogen, 0.0874, or 1.217 per 100.

Incineration.

18.17 grains gave of Ash, 1.85, or 10.18 per 100.
 6.75 do. 0.69, or 10.22 do.

Mean - - - 10.20

3. FROSTBURGH, MARYLAND. Colour of powder, brownish black.

1st Analysis.

4.85 grs. gave

Water, 2.10 = Hydrogen, 0.233, or 4.804 per 100.
 Carbonic Acid, 13.91 = Carbon, 3.793, or 78.20 do.

2d Analysis.

6.54 grs. gave

Water, 2.92 = Hydrogen, 0.324, or 4.954 per 100.
 Carbonic Acid, 18.89 = Carbon, 5.151, or 78.76 do.

3d Analysis.

5.889 grs. gave

Water, 2.45 = Hydrogen, 0.272, or 4.618 per 100.
 Carbonic Acid, 17.03 = Carbon, 4.644, or 78.85 do.

Nitrogen Analysis.

6.83 grs. gave of

Metallic Platinum, 1.145 = Nitrogen, 0.162, or 2.37 per 100.

Incineration.

14.27 grains gave of Ash, 1.66, or 11.63 per cent.
 2.28 do. 0.27, or 11.84 do.

Mean - - - - 11.73

In the first analysis, both of the Mauch Chunk and the Frostburgh Coal, there is a very decided error in the determination of the carbon; and the difference in the per centage of hydrogen in the analyses of the last-mentioned coal is much greater than I should wish. In the following table, therefore, we will take the mean of the *second* and *third* analyses only of the two varieties of coal in estimating the per centage of carbon; and the mean of the three of each variety in estimating the per centage of hydrogen. We shall not then, I am sure, commit any serious error: —

	POMEROY.	FROSTBURGH.	M. CHUNK.
Carbon - -	76.70	78.80	84.98
Hydrogen - -	5.67	4.59	2.45
Oxygen - -	11.32	2.51	1.15
Nitrogen - -	1.71	2.37	1.22
Ash - -	4.60	11.73	10.20
Total - -	100.00	100.00	100.00

4. WORCESTER PLUMBAGINOUS ANTHRACITE.

I selected for analysis those small fragments which appeared to be most free from the associated rock. It had the touch and somewhat of the lustre of plumbago; it gave a streak on paper, and the mortar in which it was triturated became coated and polished, as if from common plumbago. Dried at 120° Centig.

Analysis.

8.00 grs. gave of

Water, 0.670 = Hydrogen, 0.0744, or 0.926 per 100.
 Carbonic Acid, 8.316 = Carbon, 2.268, or 28.350 do.

Nitrogen.

I found I had not sufficient of the same specimen to make a nitrogen analysis. I ascertained, however, that what remained of the other fragments contained nitrogen. On heating in a test-tube with the soda-lime mixture, ammonia was evolved, as proved by

1. Red litmus-paper being turned blue;
2. By the appearance of dense white fumes on holding the stopper of the hydrochloric acid bottle near the mouth of the tube;
3. And, also, characteristically by the smell.

Incineration.

6.745 grains gave of Ash, 4.625, or 68.569 per 100.

We have, then,

Carbon	-	-	-	-	-	-	-	-	28.350
Hydrogen	-	-	-	-	-	-	-	-	0.926
Oxygen*?	}	-	-	-	-	-	-	-	2.155
Nitrogen		-	-	-	-	-	-	-	
Ash	-	-	-	-	-	-	-	-	68.569
									<hr/> 100.000 <hr/>

I also incinerated another portion, which evidently contained a much larger quantity of rock. Dried at 120° Centig.

28.70 grains gave of Ash, 24.21, or 84.35 per 100.

We have, then, 15.65 per 100 of carbon, etc. The incineration was conducted during 2½ hours. The colour of the ash was reddish-brown, due evidently to oxide of iron.

In the combustion I employed as much heat as I could obtain by wafting the charcoal with a piece of paste-board. The gas ceased to be disengaged *completely*, and the caustic ley rose rapidly in the bulb, and continued to rise after breaking off the drawn-out extremity of the combustion-tube. I immediately removed the charcoal. On cooling, the tube, as I expected, cracked slightly, the ley in the large bulb descended, and I was enabled to draw air through effectually in the usual way. After removing the sheet of copper, with which the tube had been enveloped, I found the glass melted in several places, and in one spot, about two inches from the drawn-out end, the glass had sunk down to the chromate of lead, and so intercepted the passage of air from the drawn-out point. Only a very minute quantity of carbonic acid could possibly have escaped absorption. I am thus particular in relating details, that you may exactly know what value to attach to the analysis, which I think must be very near the truth.

POSTSCRIPT. — Feb. 26. 1845.

I subjoin the following analysis of Anthracite from the Lehigh Summit Mine, Pennsylvania. The ash is in *very small* proportion: —

1st Analysis.

6.93 grains gave of

Water, 1.717 = 0.1907 Hydrogen, or 2.75 per 100.
Carbonic Acid, 23.57 = 6.428 Carbon, or 92.756 do.

2d Analysis.

6.854 grains of coal gave of

Water, 1.55 = 0.172 Hydrogen, or 2.509 per 100.
Carbonic Acid, 23.23 = 6.335 Carbon, or 92.427 do.

Nitrogen Analysis.

7.014 grains gave of

Metallic Platinum, 0.46 = 0.0652 Nitrogen, or 0.921 per 100.

Incineration.

33.73 grains gave of Ash, 0.75, or 2.223 per 100.
16.89 do. 0.385, or 2.280 do.

Mean - - - 2.251.

* I presume oxygen to have been present. Its presence, however, could only have been demonstrated by determining the proportion of nitrogen.

Analysis.

Carbon	-	-	-	-	-	-	-	92.591
Hydrogen	-	-	-	-	-	-	-	2.629
Oxygen	-	-	-	-	-	-	-	1.608
Nitrogen	-	-	-	-	-	-	-	0.921
Ash	-	-	-	-	-	-	-	2.251
								<hr/>
								100.000
								<hr/>

The heat employed was sufficient to melt the Bohemian combustion-tubes in several places, although protected by sheet copper.

3. *On the Geology of CAPE BRETON.** By RICHARD BROWN, Esq.
Communicated by CHARLES LYELL, Esq. F.R.S., F.G.S., &c.

I PROPOSE, in the following pages, to give a slight general sketch of the geology of Cape Breton, from notes made at various times, some so far as 15 years back, and collected more with a view to professional pursuits, than for the purposes of geological research.

The island of Cape Breton is separated from Nova Scotia by the Gut of Canso, and is about 120 miles in length from north to south, and 90 miles wide from Scatari on the Atlantic shore to Port Hood on the Gulf of St. Lawrence. A range of highlands, commencing at Cape North, continues to St. Ann's on the east shore, and to Margarie on the west shore, both distant from Cape North about 60 miles, and presents, with few interruptions, bold and precipitate cliffs to the ocean. These highlands attain their greatest elevation near the shore, constituting a table-land from 15 to 20 miles in breadth, and 600 to 1000 feet in height, in most places incapable of cultivation. Part of this table-land is covered with a stunted growth of spruce and fir trees, and the remainder is principally rocky and barren moorland, which affords a scanty supply of moss for a few herds of wild deer.

From Margarie to Port Hood the country is elevated, but undulating, being intersected by several small rivers running through valleys of great fertility. From Port Hood another chain of hills stretches towards Ship Harbour, the water shedding from the eastern declivity into the rich alluvial valley of the river 'Inhabitants,' which runs parallel with the Gut of Canso from north to south. These hills decline gently to the west, and from Port Hood to Bear Island, at the southern end of the Gut, form a low shore, which seems to suffer less than might be expected from the

* The memoir, by the same author, accompanied by a map, and published under this title in the previous pages of this volume (see *ante*, p. 23.), was chiefly intended to have reference to Mr. Lyell's observations concerning the age of the gypsum in Nova Scotia and Cape Breton. — Ed.

action of a tide running, in many places, at the rate of from 6 to 8 miles per hour. In the northern part of the Gut, the strong eddies have deposited long narrow beaches of coarse gravel, ponds or lagoons lying between them and the shore, which is thus protected from further abrasion; whilst to the southward, where the strait is narrower and the tides are more rapid, the position of the strata, consisting of strong compact shales and hard sandstones, has contributed greatly to their preservation, the strike being E. and W., or directly across the course of the current.

Proceeding along the southern shore, from the Gut of Canso to Scatari Island, the coast is low and rocky, occasionally exhibiting sloping banks of clay and gravel, until we arrive at Louisbourg, where the rugged cliffs, composed of greenstone and metamorphic rocks, defy alike the abrading action of the waves of the Atlantic and the atmospheric influences of a climate subject to great and rapid changes. There is very little land fit for cultivation along this part of the coast for several miles inland; but superior soils are found in the interior, especially on the Miray and Grand Rivers.

From Scatari to Cape Dauphin, the shore presents a continuous mural cliff, varying from 20 to 100 feet in height, except at the heads of the several bays, where low sandy beaches are invariably met with. This cliff, composed of the sandstones and soft shales of the coal formation, is subject to great waste, the rapid encroachments of the sea being noticed by the most careless observers. There can be no question but that Flint Island and the northern head of Cow Bay, now separated by a channel two miles in width, were, at no very distant period, united. The land along this part of the coast is generally low, but undulating, until we arrive at the Granite Ridge, lying between St. Ann's harbour and the ship entrance of the Bras-d'or Lakes, which ridge terminates at Cape Dauphin.

Having thus sketched the appearance of the sea coast of the island, let us next turn our attention to the interior. In the very heart of the island, there exist two capacious salt-water lakes, with innumerable bays, creeks, and islands, each of them communicating with the sea by two channels, one of which is navigable for ships of the largest class. The Grand Lake is 40 miles in length and 20 in width, from the narrows to St. Peter's Channel. In sailing from the West towards the East Bay, we have a water horizon before us, although the land at the head of the latter bay is by no means low. The scenery of the lakes is exceedingly striking, the conglomerates constituting long ranges of undulating blue hills, rising behind one another in the distance; whilst the white cliffs of gypsum stand out in bold relief on the margin of the water. The shores of the lakes are thickly studded with the cottages of thriving settlers, and a narrow belt of cultivated land stretches along the water's edge, backed by the dark shades of the forest. All the numerous creeks and channels are navigable by large vessels; and some idea may be formed of the extent of

these lakes from the fact, that there is no point in the island more than twelve miles distant from salt water.

The rivers of Cape Breton, as may be supposed from an inspection of a map of the island, are inconsiderable. The principal are Miray, Margarie, Mabou, Inhabitants, and Grand rivers, discharging into the sea; and Baddeck, Wagamatcook, and Denny rivers, discharging into the Bras d'Or Lakes. Valuable tracts of alluvial land occur on the banks of all these rivers; and in beds of this kind on the Baddeck, a tooth and thigh bone of some large animal were found some years ago and sent to England. From the description given to me, I conclude that they belonged to the mastodon. They were found in the bed of the stream after a heavy flood, having probably been washed out of the alluvium which formed the banks of the river.

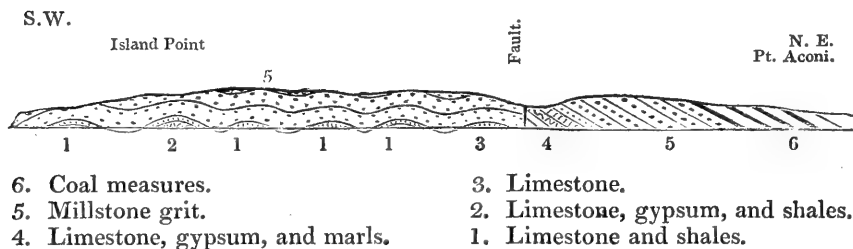
The bays and harbours of Cape Breton are numerous: many of the latter being surpassed by none on the whole coast of America in natural advantages. The principal are St. Ann's, the Great Bras d'Or Entrance, Sydney, Mainadieu, Louisbourg, Arichat, Ship Harbour, and Port Hood. Of these, Sydney is undoubtedly the best; and from its situation, in the very heart of the great coal field, is the most important. It is easy of access; free from rocks and shoals, and very capacious. After passing through the channel between the beaches (which is one mile wide, and 9 fathoms deep), it separates into two arms or branches, each of which is five miles in length, and averages one mile in width.

The coal formation is probably the most recent stratified group in the island; and it is certainly the most important, as it furnishes Newfoundland, Nova Scotia, Prince Edward's Island, and the United States with an abundant supply of coal, equal in quality to the best of that found in the Newcastle district. The coal field of Sydney, situated on the N.E. coast of the island, is the only one that has been sufficiently explored to determine its limits, and it extends from Miray Bay to Cape Dauphin, averaging about seven miles in width, and occupying an area of 250 square miles. As the general dip of the strata is north-east, or seaward, this great area of coal measures is probably the segment only of an immense basin extending towards the coast of Newfoundland — a supposition which is confirmed by the existence of coal measures at Niel's Harbour, 30 miles north of Cape Dauphin. The precipitous cliffs afford admirable opportunities for obtaining sections, but owing to numerous faults existing between Miray Bay and Low Point, the exact relations of the several seams cannot be ascertained so satisfactorily as in the district west of Sydney Harbour, which is free from any serious fault. The coal measures consist of beds of sandstone and shale, alternating with valuable seams of coal. In the natural section exhibited in the cliff stretching from Point Aconi to the commencement of the great sandstone or millstone grit, on the N.W. shore of Boulardrie Island, we have a horizontal distance of six miles, measured on the direct dip and rise of the strata, without a single fault or break; which, taking the

average inclination at 10° , gives a perpendicular thickness exceeding 5400 feet. In this thickness are contained four seams of workable coal, ranging from 4 to 7 feet each, and several small seams of less than 2 feet. It may be satisfactory to the advocates of Mr. Logan's theory of the formation of coal, to learn that all the seams above mentioned, and in fact every one that I have examined in other parts of this coal-field, rest upon fire-clay floors, containing leaves of *Stigmaria*. Vegetable remains, the same that are usually found in the coal fields of Great Britain, are also met with in great abundance; and occasionally trunks of trees, from one to two feet in diameter, are found both in vertical and in horizontal positions. Besides these, I have recently discovered fishes' scales, with teeth, fins, bones, and coprolites in a bed of bituminous shale, and in a thin seam of impure cannel coal.

The great sandstone or millstone grit upon which the coal measures repose may be traced along the southern border of the coal field of Sydney; but its thickness is variable, for it is compressed within very narrow limits at the western end, where the granitic ridge of Cape Dauphin rises abruptly behind the carboniferous limestone. The belt of limestone and gypsum which crosses Boulardrie Island about two miles to the S.W. of the crop of the coal measures, has apparently been brought up to the surface by a fault, since the same beds of limestone show themselves occasionally, cropping out from under the millstone grit, on both shores of Boulardrie to its S.W. extremity, as is represented in the following section:—

SECTION of the South-eastern Shore of BOULARDRIE ISLAND, 26 miles.

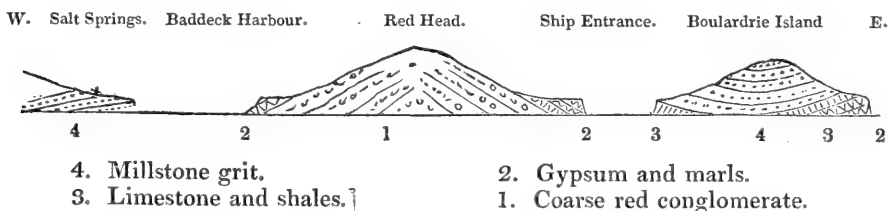


On the eastern shore of the Little Bras d'Or Lake, we have a good section of the millstone grit, from the crop of the coal measures to the mountain limestone at George's River, 2000 feet in thickness. The sandstones are generally coarse and pebbly; but some of the beds are compact and fine-grained, affording excellent building stone; false bedding is of frequent occurrence. A few beds of shale are interstratified with the sandstones; vegetable remains, such as *Calamites* and *Lepidodendron*, are abundant; and occasionally small patches of lignite are seen. The millstone grit preserves the same characteristics from hence to Miray Bay, where it comes into contact with a coarse conglomerate, and is thrown into a vertical position. One solitary *Lepidostrobus* was here found in the sandstone, being the only one yet met with in the island.

An extensive tract of millstone grit, with red shales and some thin limestones, commencing at Soldier's Cove, on the lake shore, seven miles to the eastward of St. Peter's, continues to the Gut of Canso; but I have not had an opportunity of tracing the northern boundary of these, except at the head of the West Bay, where limestone and gypsum show themselves. A few thin seams of coal, of no practical value, have been found in this tract; viz. at St. Peter's; at the mouth of the River "Inhabitants;" and at Carabacoo Cove, near Bear Island. It has not been ascertained how far the millstone grit extends up the valley of the River "Inhabitants;" but workable seams of coal are said to occur twelve miles above its mouth. A mass of trap protrudes through the grits and shales on the narrow isthmus which separates St. Peter's Bay from the lake, and there forms a conical hill, called Mount Granville, 600 feet in height. On its eastern declivity, beds of a coarse limestone are seen nearly on edge, but quite destitute of fossils. This trap is soft and crumbling, of a mixed green and white colour, and it resembles in every respect the mass of the same rock which bursts through the New Red Sandstone of Truro, in Nova Scotia.

On the western shore of Cape Breton, the millstone grit commences at the northern end of the Gut of Canso, and it underlies the coal measures which extend in a narrow belt from Port Hood to Chimney Corner, near Margarie. I have not visited this part of the island; but am credibly informed that valuable seams of coal exist at both extremities of this coal field.

One of the most characteristic features of the Cape Breton, as well as of the Nova Scotia coal field, is the constant association of extensive beds of gypsum and marls with the carboniferous limestone. These gypsiferous strata are nowhere more fully developed than in the Bras d'Or Lakes, where, most fortunately, the numerous creeks and inlets which ramify in all directions expose sections on their shores; and from these, at a future time, I trust I shall be able to collect a body of facts, that will clear up any doubts that may yet remain concerning the relative age and position of the gypsum and coal measures. In the vicinity of Sydney, gypsum appears at the head of the East Bay, and again, crossing the Boulardrie Island, following the course of the fault, as is shewn in the above section. Beyond this fault, the limestones, with the overlying sandstones, stretch out horizontally to the head of Boulardrie Island, the gypsum showing itself only at two places, viz. at Island Point and Big Harbour. The following is a section from Island Point to Baddeck:—



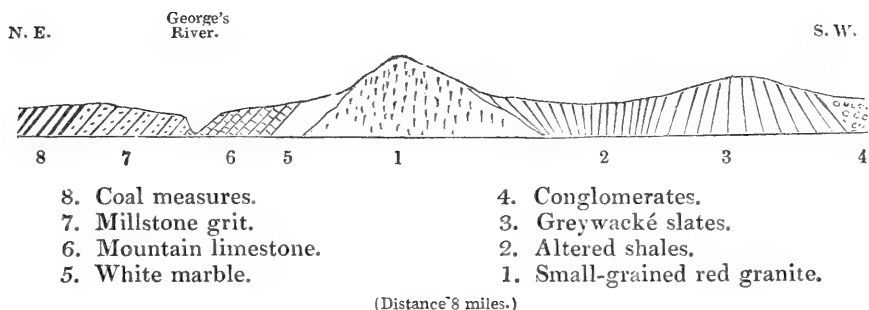
From this section, I think it is quite clear that the limestone and gypsum, dipping under the millstone grit of Boulardrie, emerge again, the former on the east, and the latter on the west side of the ship entrance, where we find this rock resting upon the conglomerate of Red Head. Crossing the promontory of Red Head, the gypsum is again seen on the east side of Baddeck Harbour, dipping apparently under the sandstone beds on the opposite shore. Further up the lakes, especially on the peninsula formed by Patrick's Channel and the river Denny, the gypsiferous strata spread out in every direction, sweeping round the bases of the lofty hills of the conglomerate, which constitute such prominent objects in the scenery of the lakes. These hills rise to the height of 400 or 500 feet, the strata of conglomerate being highly inclined, whilst the limestone and gypsum which occupy the lower ground, rarely rise 100 feet above the level of the lakes.

Salt springs are frequent in the gypsum districts; but the brine is generally weak, seldom yielding more than 7 per cent. of salt. Gypsum is also found on the shores of Aspey Bay, in the neighbourhood of igneous rocks, on the shores of St. Ann's Harbour, on the south side of Lennox's Passage, and at Plaister Cove in the Gut of Canso.

Underlying the gypsum and shales of the last-mentioned locality, we find an extensive belt of coarse conglomerate, which probably crosses the river "Inhabitants," and unites with the conglomerates of the river Denny and Ogomah Basin. In the opposite direction, it crosses the Gut of Canso, being separated from the igneous rocks of Cape Porcupine by a series of altered shales and grits of the greywacké formation; and it continues thence to the head of Chedabucto Bay.

Between Miray Bay and Louisbourg, the country is chiefly occupied by strata of fine-grained conglomerates, passing downwards into slates, and upwards, near their junction with the carboniferous limestone, into compact brown sandstones and hard red shales, analogous to the greywacké system of Europe. From Scatari Island towards Gabarus Bay, these rocks occasionally assume a crystalline texture, owing apparently to the presence of long ridges of greenstone trap interposed between the strata, which are generally vertical, or nearly so.

These parallel ridges of greenstone rise sometimes to a height of 20 to 30 feet above the general surface, and are frequently not more than 100 yards distant from one another; although it must be observed, that large areas of altered strata are met with where none of these trap rocks are visible on the surface. On the south shore of the Little Bras d'Or, similar strata of greywacké with altered rocks are also met with; but in this instance, the red granite which breaks through the limestone at George's River has changed the red shales and sandstones of the upper part of the greywacké series, and at the same time converted the limestone into white marble; the following is a section of the strata:—



At Brack's Brook, we find the greywacké slates resting upon granite and porphyry, and extending to Soldier's Cove, where they meet the red shales and sandstones of the millstone grit series. Several small troughs of an apparently recent limestone may be here observed, lying unconformably upon the greywacké.

The conglomerate of Isle Madame seems to pass insensibly into a fine-grained greywacké slate, on the south side of that island.

Rocks of igneous origin occupy a very large proportion of the island of Cape Breton; and the lofty table-land in the northern part of the island is supposed to consist almost wholly of primary rocks. The high and narrow ridge lying between St. Ann's Harbour and the ship entrance of the Lake, consists of fine-grained red granite and syenite; and at George's River, a similar granite protrudes through the limestone and greywacké as before-mentioned. On the south shore of East Bay, granites and porphyries of various composition extend from Brack's Brook to the outcrop of the mountain limestone, a distance of ten miles, forming barren naked peaks, in some instances 800 feet in height. We find also here a beautiful porphyry, having a dark-green base, with large whitish crystals of felspar. The small island of St. Paul's, which lies about twelve miles east of Cape North, in the direct track of vessels bound up the St. Lawrence, and which has proved fatal to many a noble ship, consists of mica slate, gneiss, and granitic rocks, apparently stratified in thin beds, with an E. and W. strike, and nearly on their edges.

To show the connection of the strata of Cape Breton with those of Nova Scotia, I have continued the section across the Gut of Canso to the shales and sandstones of Merigomish. It will be seen that the conglomerates on the Nova Scotia shore, which succeed the greywacke and igneous rocks of Cape Porcupine, dip under the sandstones and shales of Tracadie (including some trifling seams of coal at Pornket), and emerge to the westward from beneath the gypsiferous strata of Antigonish, reposing upon and passing into the greywacké rocks of Antigonish mountain. The conglomerate again sets in on the western flank of Antigonish mountain, and is followed by the sandstones and shales of Merigomish and Pictou.

MAY 29, 1844.

W. M. Hen. Browne, Esq., of King Street, Covent Garden, and Geo. Loch, Esq., of Albemarle Street, were elected Fellows of this Society.

A communication was read by Professor SEDGWICK, being in continuation of his Memoir "On the Geology of North Wales," read on the 29th Nov. 1843.* The notice of this paper is postponed for the present.

JUNE 12, 1844.

R. T. Atkinson, Esq., of Newcastle-on-Tyne, was elected a fellow of this Society.

The following communications were read : —

1. *On FLUORINE in BONES, its source, and its application to the determination of the geological age of FOSSIL BONES.* By J. MIDDLETON, Esq. F.G.S., late Principal of the College at Agra.

THE accumulation of fluoride of calcium in fossil bones constitutes a very interesting and important subject of inquiry in reference to Geology, since it seems to involve the element of *time*, so interesting in all geological investigations. It was with a feeling of this importance that I some time ago commenced a series of investigations, which are not yet completed, in order to ascertain the proportion of fluoride of calcium in bones that had been preserved for various periods, with a view to infer, if possible, from the mineral condition, the relative ages of the specimens.

The bones hitherto examined by me with this view consisted of some from the Sewalik Hills furnished to me by my friend Dr. Falconer, and some, for the permission to examine which I am indebted to the authorities of University College, London, in the chemical laboratory of which institution my investigations have been conducted. Among these last were the bones of a Greek, who had lived, it is supposed, about the time of the second Peloponnesian war (a coin of that period being found under the jaw of the skeleton), and a part of an Egyptian mummy in a remarkably perfect state of preservation. The Sewalik fossils were of the soft kind †, those embedded in the clay in that locality, as they seemed better suited for comparison with bones of recent and known age and with those of early tertiary periods.

On examining these bones, I found that those from India con-

* See *ante*, p. 5.

† So named, I believe, by the gentlemen who found them, to distinguish them from those largely penetrated by oxide of iron or silica.

tained all of them nearly the same proportion of fluoride of calcium, viz. 11 per cent., while in the bones of the Greek the proportion was only a little more than 5 per cent., and in the mummy about 2 per cent. The difference in the two latter is accounted for, it would seem, by the circumstances of deposition, this being sufficiently evident from the appearance of the specimens; since the bone of the Greek has assumed a soft powdery character, tinged with peroxide of iron, the result of exposure to atmospheric and other influences, while that of the Egyptian exhibited all the structure of recent bone, having been preserved in a sarcophagus, and scarcely changed from its normal state.

From these results, and from having ascertained the presence of fluorine in the recent bones both of men and reptiles, I was led to suppose that the presence of fluorine must be due to some general condition, the same in ancient times as at present, for I could not believe that in this matter there could be any alteration in the laws of organic life, implying different proportions of the mineral at different periods. I was thus led to suspect that water might be the agent producing this apparent change; and this seemed to me to offer a ready solution of the whole problem. That there is a great tendency in fluoride of calcium to unite itself to phosphate of lime, is evident from the almost universal association of the two in nature; and thus, if the moisture constantly present at the earth's surface should contain the mineral in question, the bones might absorb it by simple exposure; a larger proportion being obtained, according as the bones had been longer exposed to its influence. Bearing this in mind, I was led to institute a series of experiments on aqueous deposits of different ages, and I found that, with one exception, — a pure but incompact stalactite of carbonate of lime, — fluorine exists in all, from the most recent deposit down to the old red sandstone, and that it is present in the older in larger proportion than in the newer beds. I think it is therefore beyond a doubt that it is present in water, though perhaps in very minute quantity; what its solvent may be I know not, but that it is so held in solution my own experiments have demonstrated; and if they had not, the simple fact that the blood conveys it to the bones, would, I apprehend, sufficiently refute any scepticism on the subject.*

It now remains for me to show, that the relative geological age of rocks may be estimated by the proportion of fluoride of calcium which they contain; and for this purpose I append the following results of my analyses in the cases of recent bone, the bone of a Greek already alluded to, a fossil bone from the Sewalik

* *Note by the President.* "I am informed by Professor Graham, that he is well acquainted with these researches of Mr. Middleton; that, previous to his return to India, Mr. Middleton ascertained the presence of fluoride of calcium in the deposit obtained by boiling the ordinary pipe-water supplied to the houses in London; and that there is reason to believe, from this and other observations, that the fluoride of calcium is held in solution by the carbonic acid usually present in water." — *L. H., April 7. 1845.*

Hills, and a bone of the *Anoplotherium* ; the latter being given by Lassaigne : —

	Recent Bone.	Bone of the Greek.	Fossil Ruminant, from the Sewalik Hills.	Bone of the Anoplotherium.
Organic matter - -	33·43	9·97	—	
Phosphate of lime - -	52·11	70·01	78·00	37·00
Carbonate of lime - -	10·36	10·34	11·34	
Fluoride of calcium - -	1·99	5·04	10·65	15·00
Chloride of sodium - -	·60	} 1·15	} a trace	
Soda - - - -	1·08			
Magnesia - - - -	·76	} 1·34		
Phosphate of magnesia - -	·00			
Silica - - - -	—	1·68	—	35·00
Peroxide of iron - - -		about ·25		
Alumina - - - -	—	—	—	10·00
Oxide of iron & manganese				3·00

In comparing together the quantities of fluoride of calcium in bones of different periods, we should be guided, I apprehend, by the proportion it bears, in each specimen, to the fixed basis of the bone, phosphate of lime, a substance which seems but little liable to variation in amount. The comparisons stand thus : —

	Phosphate of Lime.	Fluoride of Calcium.
Recent bone - - -	52·11 - -	1·99
The Greek's bone - -	70·01 - -	5·04
The Sewalik fossil bone - -	78·00 - -	10·65
The <i>Anoplotherium</i> bone - -	37·00 - -	15·00

When the animal matter, entirely obliterated in the fossil bones, has been suppressed in the recent bones, we have — :

	Phosphate of Lime.	Fluoride of Calcium.
Recent bone - - -	77·84 - -	2·97
The Greek's bone - -	78·55 - -	5·62
The Sewalik fossil bone - -	78·00 - -	10·65
The <i>Anoplotherium</i> bone - -	37·00 - -	15·00

If now, for convenience of computation, we represent the phosphate in each case by 100, we obtain the following ratios of the fluoride : —

Recent bone - - -	3·81
The Greek's bone - -	7·15
The Sewalik fossil bone - -	13·01
The <i>Anoplotherium</i> bone - -	40·54

Now, as the age of the Greek's bone is known to be 2000 years, we obtain, if my hypothesis be just, the following values, in time, of the above ratios of the fossil bones : viz. the Sewalik fossil, 7700 years ; the *Anoplotherium*, 24,200 years.

2. NOTICE *of the RAISED BEACHES on the WESTERN COAST of ROSS-SHIRE.* By J. G. JEFFREYS, Esq.

(Communicated by the Rev. Professor Buckland, D.D.)

ABOUT two miles above Craig Inn, and eleven from the present termination of Loch Carron, there is a level platform extending for some distance in a parallel line with the valley up which the loch at present flows, elevated about 50 feet above the present sea level, and sloping at an angle of 45° , and its breadth seems the same as that of the present beach at its foot. Sixteen miles from the termination of the loch is a similar platform with the same direction and slope, but apparently at a higher level; and on the opposite side of the loch (which is about half a mile wide in that part) is a corresponding platform, similar in every respect to the other. This is outside the loch, about a mile below Strome ferry, which forms the entrance to it. Some miles further down the main channel of the sea, at a place called Plockton, the same appearances present themselves; and here the elevation is about 60 feet above high-water mark.

On examining this latter platform, I found underneath the superficial stratum of earth a bed of coral and shells two or three feet thick, and precisely similar to the beds which, as I ascertained by dredging, exist in the adjoining sea. The depth of the sea varied from three to upwards of a hundred fathoms.

At Applecross similar indications of a former beach are to be found, and also at Shieldaig near the mouth of Loch Torridon, and at Gairloch, on the same coast. In the former locality (Applecross), the platform or bank appeared to be almost entirely composed of coral and shells. In the neighbouring sea prodigious quantities of testaceous and calcareous mud appear to be accumulating.

I would further remark that the platforms in question do not appear to have been formed by drift, or by the ordinary action of the winds and waves, because their base is beyond the reach of any tide, and at the mouth of Loch Carron they are situated on both sides of the channel, and are consequently exposed to different winds and currents of the sea. The whole appearance seems referable to a sudden elevation of the land by means of some subterranean convulsion.

It is worthy of remark, that on the eastern coast of Scotland, particularly on the Moray Frith, trunks of trees are found embedded in the sands at low water, thus showing a subsidence or depression of the land on that side.

3. *On the Cliffs of NORTHERN DRIFT on the Coast of Norfolk, between WEYBOURNE and HAPPISBURGH.* By JOSHUA TRIMMER, Esq. F.G.S.

In this paper the author proposes to describe certain changes that have taken place in these cliffs, comparing the appearances they present with those of raised beaches in North Wales.

With regard to the former subject, he notices first, the condition of a pinnacle of chalk at Old Hythe Point. The cavity at the summit of this pinnacle is now exposed to a greater depth than in Mr. Lyell's drawing*, and the sand and gravel with which it was filled are removed. No vertical strata of sand to the N.E. of the pinnacle are now visible, and these must have been removed by denudation. Mr. Lyell's statement that this pinnacle is separated from the great mass of the chalk by the crag deposits, is, in the opinion of the author, confirmed by the position in which the chalk rests.

Of the protuberances of chalk near Trimmingham, the northern and middle seem now little changed, but the southernmost has undergone some alteration. Its length is still the same as when visited by Mr. Lyell, but it is reduced to nearly half its height, and the waves have washed away a portion of the overlying gravel at one extremity. The next fall of the cliff will probably bury this end of the protuberance entirely. The chalk inland seems tilted, and is covered with a breccia of the crag.

About a quarter of a mile east of Cromer, the author met with a bed of peat, resting on pyritous silt and gravel, and resembling a peat bed at Mundesly, and the stem of a small fir tree was here observed in a vertical position. Between Mundesly and Trimmingham he observed other instances of peaty beds associated with the same kind of gravel, and he endeavoured to determine whether the *till* and the freshwater deposits were contemporaneous. This he decided in the affirmative, at least for the upper portion of the freshwater beds, since at Cromer he found, at the height of 20 feet from the beach (about 300 yards west of the jetty,) several bands of black peaty mud, a few inches thick, alternating with laminated blue clay, derived from an adjoining mass of the unstratified till, which elsewhere overlies the freshwater beds.

At Runton, near the Gap, the freshwater beds are covered by a regular marine deposit of the crag. A black peaty bed, about 4 feet thick, containing shells of *Cyclas*, *Planorbis*, *Helix*, and fragments of *Anodon*, together with some vegetable remains, rests on a ferruginous sand, containing *Anodon*. The peat is covered by a bed of gravel about a foot thick, containing *Fusus striatus*, *Tellina obliqua*, *Mya arenaria*, and *Natica helicoides*, and some of the shells of *Mya* exhibit the valves united, but they are too fragile to

* See Phil. Mag., May, 1840.

be readily extracted. There is here no mixture of fluviatile and marine remains, so that this instance offers evidence of submergence and subsequent elevation. The marine gravel is covered by laminated blue clay, derived from adjoining till, and it passes upwards into yellow silt and sand, the lamination of which is much contorted.

Till. The unstratified blue clay on the Norfolk coast alluded to under this name, resembles, in colour and composition, that which is found on the coast of North Wales and the east of Ireland, differing only from these deposits in the nature of the imbedded fragments. These seem to have been all of them transported from the north, and they are heaped in irregular hummocks, the height of the cliffs depending on the amount of this material. The till does not seem to pass by any gradation from the fresh-water deposits, nor is the surface of the latter disturbed at the contact as if the sea-bottom had been ploughed up by the passage of icebergs. The contorted strata (accurately described by Mr. Lyell) are always either above or between the masses of till.

The transported blocks dispersed through the till consist of granite, gneiss, mica-slate, and trappean rocks, often in an angular state, and not rubbed. Some fragments, however, show scratches and other markings like those attributed to the grinding of a glacier, and the author states that he had already observed scratches on boulders in Caernarvonshire, and alluded to them as characteristic of the epoch, before such markings were attributed to the action of ice.

Notwithstanding the distance which separates the till of the coast of Norfolk from that of North Wales and Ireland, the author recognises a common character pervading the whole, which he attributes to their having had a common origin, being derived from the north, and he considers that the cause of the deposit of this boulder clay covered with sands, loam, &c. of a yellow colour, seems to have acted but once, the same appearances not recurring. There is still, however, one striking difference observable in the two localities, since the Norfolk beds are much contorted, while this is not the case in North Wales. These contortions are referred by the author to the movements connected with the final upheaval of the coast; but since, where the contortions are most violent, the underlying chalk is undisturbed, as between Sherringham and Weybourne, he supposes that the till has exercised some influence in producing these singular appearances.

The author observes, in conclusion, that these deposits on the cliffs produced by the northern drift, ought to be carefully distinguished from ordinary raised beaches, the phenomenon in the former case having been produced by the submergence and subsequent elevation of land which had been long existing in that state. He does not pretend to decide the extent of the submergence.

JUNE 26, 1844.

John Shaw, Esq., M.D., of Hop House, Boston, Lincolnshire, was elected a Fellow of this Society.

The following communications were read: —

1. *On the STONESFIELD SLATE of the COTTESWOLD HILLS.* By the Rev. P. B. BRODIE, M.A., F.G.S., and JAMES BUCKMAN, Esq., F.G.S.

THE district alluded to in this memoir is situated to the east of Cheltenham, and includes the Cotteswold Hills, which divide the county of Gloucester from parts of the neighbouring counties of Oxford, Worcester, and Warwick.*

The formations occurring in this district are the following: —

GREAT OOLITE -	{	7. Clays representing the Bradford clay, or those dividing the beds of the great oolite in Wiltshire.
		6. STONESFIELD SLATE and ragstone.
INFERIOR OOLITE	{	5. Fullers' earth.
		4. Inferior oolite.
LIAS - - -	{	3. Upper lias shale.
		2. Marlstone.
		1. Upper shales of the lower lias.

1. *Upper Shales of the Lower Lias.* These consist of blue argillaceous deposits, sometimes, especially towards the top, intermixed with clays of an ochreous yellow colour. The following are amongst the most characteristic fossils: —

Belemnites elongatus	Pinna lanceolata
Ammonites Henleyi	Lima antiquata
Crenatula ventricosa	Arca Buckmanni
Cardinia (<i>Pachyodon</i>) attenuata	Terebratula rimosa
Modiola cuneata	Trochus imbricatus

And some undescribed species of Gervillia, Arca, and Spirifer. The beds below the above present the usual lower lias fossils.

2. *Marlstone.* A hard sandy stone, blue when first quarried, but weathering of a brown colour. It forms the terraces seen on the first ascent to the Cotteswold Hills. These terraces, however, being covered with grass, the rock is best studied in outliers, such as are found at Churchdown, Dumbleton, &c., where the stone is quarried for road-making. The following fossils are peculiar to the marlstone in this neighbourhood: —

* See a paper "On the Structure of the Cotteswold Hills, and Country around Cheltenham," by Roderick I. Murchison, Esq., read the 14th March, 1832, and published in the Proceedings of the Geological Society, vol. i. p. 388. It was afterwards printed as a separate tract.

See also a "Report of a Survey of the Oolitic Formations of Gloucestershire," by William Lonsdale, Esq., read the 19th of December, 1832, and abridged in the same volume, p. 413.

Ammonites heterophyllus	Pinna affinis
spinatus	Spirifer (two new species)
Stokesi	Terebratula tetraëdra
Gryphæa gigantea	acuta
Pecten æquivalvis	bidens
Cardium truncatum	

3. *Upper Lias Shale.* A blue argillaceous deposit containing septaria. It is recognised on the hills by exhibiting a line of drainage; and is traversed by a thin seam of fissile limestone, containing remains of fishes, insects, and shells described lately by one of the authors. The following are the prevailing fossils:—

Ammonites Strangewaysi	Inoceramus dubius
Walcotti	Plicatula spinosa
annulatus	Nucula claviformis.

4. *Inferior Oolite.* The lowest bed of the inferior oolite in this district is a pisolitic rock, composed of rounded or flattened grains about the size of peas, cemented by a calcareous paste, and containing fragments of Pentacrinites, &c. *Cidaris subangularis* and *C. coronata*, *Pecten lens* and *Avicula contorta*, are the chief fossils of this bed.

A roestone of a yellowish-white colour succeeds this pisolite, and it is found to exhibit numerous small shells on careful examination under the microscope. The average thickness of this bed is 15 feet; and the following fossils are found in it, besides the microscopic ones:—*Cardita similis*, *Plagiostoma duplicatum*, a *Nucula*, a *Cucullæa* (M. C. t. 549. fig. 3.), *Patella rugosa*, and *P. nana*.

Overlying the roestone is a thick bed of white freestone worked in large blocks. This rock is about 25 feet thick, and is a fine-grained oolite intermixed with comminuted fragments of shells. It is overlaid by about 10 feet of oolite marl, resembling chalk, and having an uneven fracture. At Leckhampton and other places it abounds with fossil shells; but at Crickley and Birdlip, to the S.W. of the Cotteswold, it puts on the character of a coralline rock. The following list of fossils includes those most characteristic:—

Astræa agaricites	Astarte elegans
Madrepora limbata	Pinna tetragona
Agaricia lobata	Terebratula fimbria
Meandrina explanata?	Natica macrostoma
Tubipora?	hemispherica
Plagiostoma læviusculum	Nerinæa fasciata

A Gryphite grit, a rough kind of stone, separated from the oolite marl by about 4 feet of flaggy oolite, next succeeds. It abounds with the shells of *Gryphæa dilatata* in its lower part, and the overlying beds of marl and compact stone are partly composed of immense masses of *Trigonia costata* and *T. clavellata*. Besides these the rock contains the following species:—

Trigonía striata
 Maetra gibbosa
 Amphidesma securiforme
 decurtatum
 Pholadomya ambigua
 lyrata
 Modiola (four species)
 Cucullæa oblonga
 Perna mytiloides
 Pecten vimineus
 Terebratula perovalis

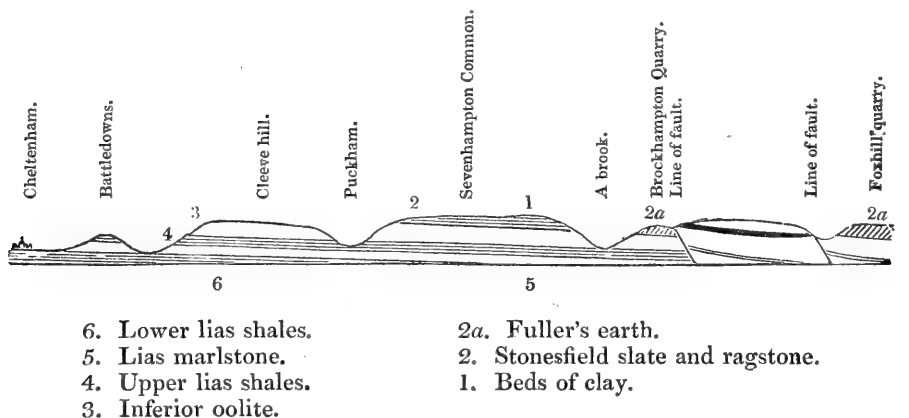
Terebratula concinna
 spinosa
 resupinata
 maxillata
 and six others
 Cirrus carinatus
 Melania striata
 Nautilus truncatus
 Ammonites Parkinsoni
 Browni
 corrugatus

These beds are capped with a band of sand and clay containing nodular masses of oolitic stone, and a great number of *Clypeus sinuatus*.

5. *Fuller's earth*. This is a yellow argillaceous deposit, which seems to be about 10 feet thick, but it presents few points of interest. Its outcrop is marked by a line of springs.

6. *Stonesfield slate*. This is the bed which it is the object of the present memoir chiefly to describe.*

SECTION. No. 1.



The first quarries of this flagstone described are situated on the top of a hill at Sevenhampton common, and the rock is generally very rich in organic remains. There are here three quarries at which the slate is worked, within the distance of half a mile from one another. One of them exhibits about 15 feet of coarse fissile ragstone, containing fossil remains of fishes and some shells, and passing downwards into the true Stonesfield slate. In another this ragstone, of about the same thickness, is occasionally intermixed with slabs of hard slate having blue centres, and there is then about 4 feet of true fissile Stonesfield slate, the upper slabs of which are used for tiling; but the lower part is sandy.

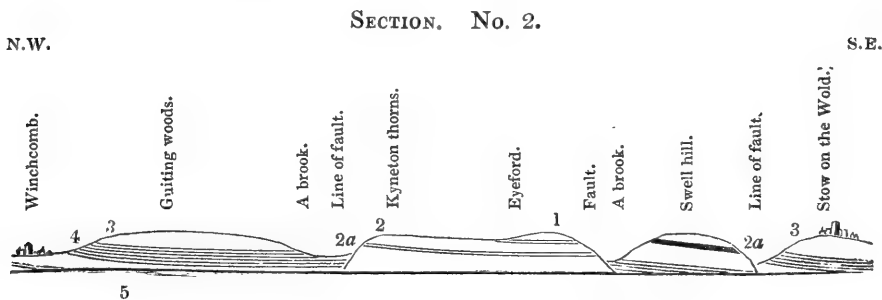
* The authors consider that the beds so called were only partially known to Mr. Murchison, and they disagree with some of Mr. Lonsdale's conclusions.

Numerous fossils have been obtained from this quarry, and the most perfect remains of plants have been found. These, as far as can be ascertained at present, consist of *Coniferæ* (two species, one of which greatly resembles the *Thenyites*, if it be not a new species); *Palmæ*; *Cicadææ*; *Liliacææ*; and two species of ferns; besides leaves of plants of too anomalous a kind to be determined. Stems of trees, much broken, occur in considerable quantity. Silicified wood of a coniferous tree has also been obtained from the above quarry. The third quarry exhibits little difference, except in the better marked subdivisions of the overlying beds, but the wing cases of beetles, and sauroid and fishes' teeth, are more frequent.

The next place at which the Stonesfield slate is worked seems to have been laid bare by a fault. It is about half a mile from Brockhampton Hill (see section above), and appears in a valley surrounded on all sides by hills which are capped with inferior beds. From this spot the beds of Stonesfield slate run in a N.W. direction; and at Kyneton Thorns and Eyeford are many quarries from which the slates are extracted for roofing.* The following is the sequence exhibited at one of the best quarries:—

- | | | | | | |
|---|---|---|---|---|--------------|
| 3. Rubble and superficial detritus | - | - | - | - | 3 to 4 feet. |
| 2. Ragstone, not very fissile | - | - | - | - | - 13 " |
| 1. Stonesfield slate, a compact sandy stone, very fissile, especially after exposure to frost | - | - | - | - | 5 " |

A new species of *Asterias*, and a species, also new, of *Pollicipes*, were found beautifully preserved in the quarries at Eyeford. *Belemnites canaliculatus* and *B. fleuriansus*, some remains of plants, the teeth and palates of fishes, and a tooth of *Megalosaurus*, have all been obtained from this locality.



(For a description of the strata, see Section No. 1.)

The eastern edge of the Stonesfield slate of the Cotteswolds exhibits the ragstone much thicker, and of a coarser kind. The quarry at Upper Swill, near Stow on the Wold, seems to show

* From one quarry alone 120,000 roofing slates are obtained in the course of a season. The work is thus conducted:—At the latter end of the year a quantity of stone is raised from the quarry, and spread over the surface of the ground. Being thus exposed, it loses the bluish tint presented when first quarried, and becomes light-coloured; this change, the result of weathering, rendering the slate more readily separable into tiles. The best tiles are said to be made from the middle of the beds.

marks of the fault already alluded to. From this quarry large reptilian bones and fishes' teeth have been obtained, and other fossils, such as *Clypeus sinuatus*, *Plagiostoma cardiforme*, *Pecten vagans*, *Ostrea acuminata*, a *Nerita*, and other shells. Not far from this, at a place called Wagboro' Bush, is a quarry not now worked, but the fossils from which are considered by the authors to identify the rock with the well-known beds at Ancliffe. These fossils are *Nerita spirata*, *N. minuta*, *Actæon cuspidatus*, *Nucula mucronata*, a *Corbula*, and a *Cerithium*.

The district described in the preceding account of strata has been subject to disturbances, the result of which has been the production of several lines of faults. One of these is represented in the preceding diagram. (Section No. 1.)

The beds from Cheltenham across the hills preserve their regular order and dip (seldom exceeding 10°); the upper beds of the inferior oolite marking the highest points of the Cotteswold range. From Brockhampton the higher ground proceeds about a mile and a half in a northerly direction to Charlton Abbotts (which is higher than Brockhampton Common): it then turns suddenly to the east, bounding Kyneton Thorns, which is situated in a fault valley extending from Kyneton to Eyeford.

The line of fault from Brockhampton is continued for about a mile to the south, where it takes a sudden turn, and is continued in irregular lines to the south-east, joining the eastern line at Stow-on-the-Wold.

There are other minor faults in the district, but they do not affect the Stonesfield slate formation.

There is evidence of denudation in the district under review, the upper clays being frequently absent: besides that the slopes of the hills are more or less covered by waterworn debris, and smaller deposits fill up hollows in the valleys to the depth of 20 or 30 feet.

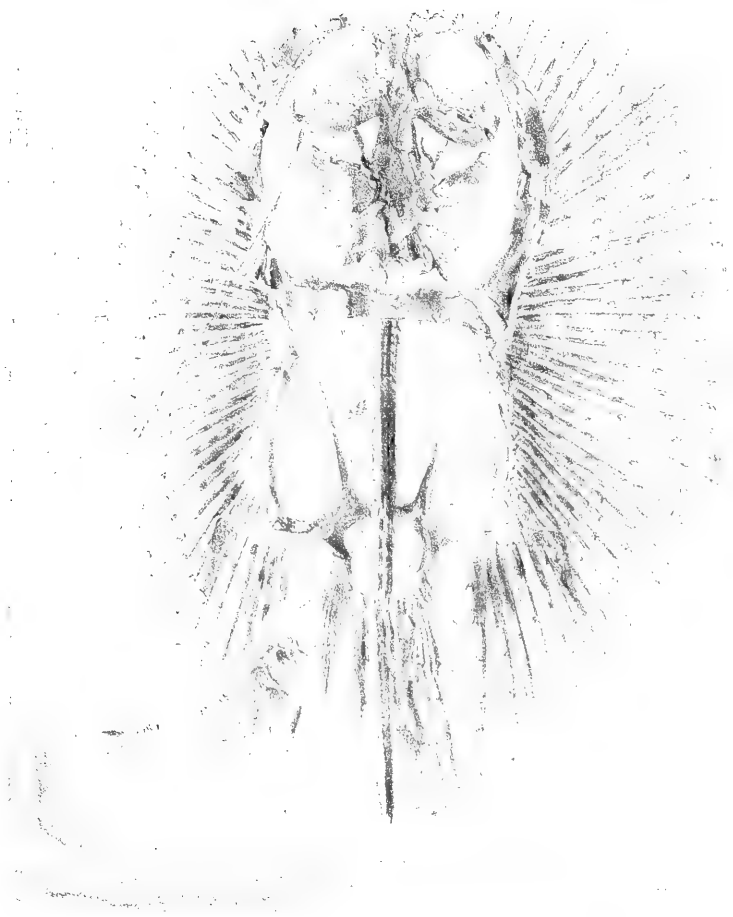
The Authors conclude with the following general summary:—

“From the foregoing examination of the upper beds of the Cotteswold Hills, we are led to the following conclusions:—

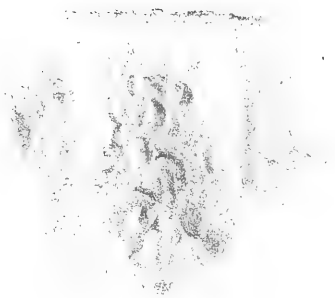
1st. That the Stonesfield slate occupies a considerable extent in the Cotteswold range of Hills, as we have traced it over a district which would scarcely be enclosed within an area of fifty miles; and that this formation, as it occurs in this part of the country, is identical with that at Stonesfield, both in its lithological and zoological characters; indeed it is clearly traceable, with few interruptions, from Sevenhampton, within five miles of Cheltenham, to Stonesfield near Blenheim in Oxfordshire.

2dly. That the Stonesfield slate in the district above described is so intermixed with the ragstone, particularly at the edges of the formation, as to be scarcely, if at all, separable from it, and (as has been shown) this ragstone presents fossils of a like character with those of the great oolite. We are thus led to adopt the conclusion, that the Stonesfield slate is part of the Great Oolite

1



2



formation, or at least not sufficiently distinguishable from it, to entitle it to rank as an independent formation; but, inasmuch as the Great oolite very much thins off where associated with Stonesfield slate, it would appear that the Stonesfield slate and its accompanying "ragstone" were deposited by the same sea which formed the Great oolite itself, and that it partly owed its origin to certain mixed conditions, arising from the influx of rivers into an ocean interspersed with numerous scattered islands, abounding in a luxuriant vegetation, and inhabited by numerous terrestrial animals; and this opinion seems more probable from the quantity of plants which occurs throughout the Stonesfield slate beds, and also from the relics of land animals, such as the *Didelphis* and *Pterodactylus*.

We also find that the Great oolite thins out towards the northern end, whilst the Inferior oolite thins out in like manner towards the southern end of that long chain of hills of which the Cotteswolds form a part.

3dly. If the beds just referred to belong to the Great oolite, it is just possible that the clays by which they are super-imposed in this district, may be the equivalent, or a sort of representative of the Bradford clay, judging at least from their position and the analogous fossils which they contain. Or, supposing this to be incorrect, we venture to conclude that these clays are the equivalent of certain clay-beds containing *Apiocrinites*, which in Wiltshire separate the freestone from a lower stratum of freestone of a coarser texture.

2. *Description of a FOSSIL RAY from MOUNT LEBANON* (*Cyclobatis oligodactylus*). By Sir PHILIP GREY EGERTON, Bart. M.P., F.R.S., F.G.S.

I AM indebted to the liberality of Professor Edw. Forbes for many valuable specimens of fossil fishes, procured by Capt. Graves from the Lebanon range; and amongst the number, for the subject of the present memoir, one of the most interesting and remarkable ichthyolites ever brought to light by palæontological research. The cases of the discovery of fishes belonging to the placoid order, in a condition at all approaching to completeness, are exceedingly rare. The destructible nature of the endoskeleton, and the loose attachment of its component members, attest the probability that decomposition would complete its work ere these records could be engrossed in imperishable characters. That this order was nevertheless extensively represented from the earliest fossiliferous period to the present time, is manifest from the frequent occurrence of the palatal tritores, teeth, and defensive fin bones of the Cestracionts, Hybodonts, and Squales; and of the dental apparatus, caudal weapons, and dermal tubercles of the Rays.

The specimen presented to me by Mr. Forbes is a remarkable exception to the general rule, the parts being perfectly preserved, so far as they are exhibited by the fracture of the matrix. The fish is in its natural position *ventre à terre*. The dorsal integuments being removed, the skeleton is distinctly exposed as seen from above. The outer margins of the pectoral fins, and the caudal vertebræ from the termination of the ventral fins, are deficient. The preservation of the claspers proves it to have been a male, and (to judge from the development of these organs) of mature age. It corresponds in size with the unique specimen of *Asteroderma* from the Solenhofen oolite in the collection of the Society, but has little resemblance in other respects to that genus. The negative facts of the absence of all trace of dermal armature, as also of the caudal ribs described in the "Poissons Fossiles," would sufficiently distinguish it; we have, however, the positive evidence of the structure of the vertebral column, which is that of a true ray, without any approach to the squaloid character displayed in *Asteroderma*. As compared with the recent genera, the circular form of the head eliminates the Lebanon Ray from all save the Torpedos. From the latter family it is distinguished by the smaller number and greater length of the rays of the pectoral fins, by the smaller size of the ventral fins and the tail, as also by other characters, which will be sufficiently manifested in the sequel. The aspect of this fossil is very singular: it may not inaptly be compared to the figure 8, surrounded by a circular border of long divergent rays. The generic name of *Actinobatis* at first struck me as conveying a good idea of this peculiarity; but, finding that Agassiz had already appropriated this title to a fossil Ray of which some dermal tubercles have been found at Plaisance, I have substituted the name *Cyclobatis*, which expresses equally well the most striking character of this singular fossil. The anterior or cephalothoracic cavity is circumscribed by the carpal bones carrying the fin digits, which join the rostral cartilage at an obtuse inverted angle. The mouth extends nearly from side to side; the teeth are only seen near the symphysis of the jaw, where they are small and discoid; the tympanic pedicle, extending from the angle of the jaw to the cranium, is broad and strong. The cartilages of the head are crushed; but the cranial cavity appears small, as also the orbits. Traces of the branchial apparatus are preserved; but the number of the arches cannot be decyphered. The cartilages composing the thoracic girdle, which forms the fulcrum for the action of the pectoral fins, are broad and strong. The anterior carpal ossicles are also largely developed, being at least a third broader than in a recent ray of similar size. These dimensions are continued until they abut against the anterior part of the head. The posterior prolongations of the carpal apparatus diminish in size as they recede from the thoracic girdle, and terminate at the insertion of the last pectoral digit a little behind the pelvic arch. The pectoral fins are very remarkable, and contribute chiefly to the peculiar characters of this ray.

They extend anteriorly to the nasal cartilages, completely surrounding this portion of the cephalo-thorax: the distal margins exceed those of the ventral fins. The component digits are 47 on each side. They increase in length and breadth as they recede from the head, the terminal ray being the largest of the series. In the recent Rays the pectoral digits number from 80 to 100, and in the Torpedos nearly 60.

The arrangement of the fin rays in *Cyclobatis* resembles that of the recent Rays, radiating in regular gradation from the centre to the extremities, but the smaller number of the digits causes their divergence to be greater, and the interspaces consequently of larger extent. The actinated appearance of these organs is due to this peculiarity, which has suggested the title of *oligodactylus* for the species. The form of the phalanges is intermediate between that of the Rays and that of the Torpedos, combining a greater length and denser structure than we find in the latter, with breadth and thickness exceeding the comparative dimensions of these parts in the former. The digital articulations are more distant and fewer in number than in the recent genera. The fork occurs at the sixth articulation,—in the recent genera not before the tenth. The phalangeal ossicles do not contract in diameter between the articulations; they have a projecting longitudinal midrib, from whence they slope off to the margin, so that a transverse section would show a lozenge-shaped outline. The coarse granulated structure of these bones is distinctly traceable, causing a jointed appearance between the articulations. The abdominal cavity, or that portion behind the thoracic girdle, is nearly as large as the anterior or cephalothoracic, and in this respect differs most remarkably from the Torpedos, where the anterior area is at least twice as large as the posterior. In form it is slightly oval; the pelvic arch differs from that of all the recent Rays I have had opportunities of consulting, in the developement of two elongated styloid processes, from the horns of the transverse pubic cartilage, and extending forwards over two thirds of the abdominal cavity. This structure recalls vividly the marsupial bones of the Australian mammals. The transverse cartilage of the pelvis sends out two broad processes, extending backwards for the attachment of the ventral fins. The proximal digit on either side is unusually large; it extends laterally at right angles to the spinal column, and at the first articulation forms a second right angle; the remaining phalanges being directed backwards, parallel to the spinal column. This digit is detached from the remainder of the ventral fin, and is inserted considerably nearer the transverse cartilage. The other fin rays are six in number on each side: the first is considerably smaller than the succeeding five, and curves outwards. The remainder agree in character with the pectoral digits. The tarsal bones which support the ventral rays, are considerably smaller than in the recent Skaits, in accordance with the smaller number of these bones, which in the latter species range from fifteen to twenty. The impressions of the claspers show these organs to have been compa-

ratively large, and of complicated form. The whole of the pelvic apparatus, with its appendages, as compared with the rays of the present period, presents remarkable modifications. The small size of the ventral fins is conclusive evidence against the supposition that these differences could have relation to locomotion. If we seek to explain them with reference to the internal structure of the animal, the absence of the soft parts deprives us of the means of arriving at any satisfactory results. Analogical considerations, however, would suggest the idea, that the peculiar features of these parts have some relation to the generative system. The vertebral column corresponds with that of the recent rays in the form and character of the vertebræ, and has no approximation to the squaloid type found in the fossil Ray from Solenhofen, in the Society's collection. The anteroposterior dimensions of the vertebræ are rather greater than in a specimen of *Raia* of similar size with the fossil: the extremity of the tail is deficient, but judging from the rapid contraction of the caudal vertebræ preserved in the specimen, this organ must have been small and powerless, presenting a remarkable contrast to that of the torpedos. There is no trace of the existence of a defensive weapon; nor, indeed, would the proportions and form of this part of the specimen lead one to infer that this fish could have been provided with such an organ.

To recapitulate the features of this remarkable fish, we have a small ray, much resembling those of the present period, but entirely surrounded by a broad flexible cartilagino-membranous fin, the skin smooth, the teeth and eyes small, the tail slender, and no trace of dermal spines, tubercles, or defensive weapons. It is impossible to resist a speculation, as to how an animal apparently so destitute of the means of offence or defence could have existed. We find in the recent Rays various provisions adapted to these ends. *Trygon* and *Myliobatis* are armed with weapons so powerful and deadly, that they have been adopted by savage nations for the armature of their war spears. Other genera have the nasal cartilages prolonged in the form of a cut-water, to enable them both to evade by flight those enemies they could not encounter in single combat, and to overtake the smaller fishes on which they subsist; and most of the recent forms have their integuments studded with spines or osseous plates, forming a species of defensive armour for the body, while a similar armature on the long and flexible tail renders this organ an effectual weapon for keeping intruders at a respectful distance. Our fossil possessed none of these advantages: the large development and anterior extension of the pectoral fins must have rendered the locomotive efforts of *Cyclobatis* little more effectual than the systole and diastole of a Medusa. The safety of the fish, then, could not depend upon flight. But these organs, however ill adapted for speed, are admirably formed for concealment, and when applied to the sand at the bottom of the ocean, would act as the leather suckers with which mischievous boys draw up the paving-stones in the streets, retaining the fish stationary, while

the smoothness of the skin would present no obstacle to the passers by, and possibly its colour may have contributed to render the concealment more effectual. The position of the mouth forbids the idea that this Ray buried itself in mud, as the *Lophius* and other predatory fish are known to do. The difficulty of defence being thus surmounted, we have still to devise how this fish procured its subsistence. It may be that it fed upon some of the smaller and more helpless denizens of the deep; but at the same time I am inclined to believe, from a comparison of the oral apparatus with the recent forms, that its food was not dissimilar. Some of these forms, too, if found in a fossil state, would cause the zoological reasoner full as great embarrassment as the subject under discussion, from the absence of the ordinary provisions for self-preservation so familiar to all. Yet the Creator of the Universe has not formed them helpless; so far otherwise, he has endowed them with a subtle armoury, more powerful than the dental *chevaux-de-frise* of the marauding shark, — more deadly than the serrated lance of the fireflare, — more effectual than the speed of the dolphin, or the aerial excursions of the flying-fish. I allude to the electric apparatus of the Torpedo. The Lebanon Ray in many points of structure has presented analogies with this genus; and although, in the absence of all positive evidence to the fact, it would not be justifiable to infer that it was provided with a similar organ, yet I do not conceive that in drawing attention to this consideration in the passing allusion I have made above, I have overstepped those bounds of probability which ought to be rigidly observed by every observer in the rich and inexhaustible field of nature.*

3. *On some New Species of FOSSIL FISH, from the Oxford Clay at CHRISTIAN MALFORD.* By Sir PHILIP GREY EGERTON, Bart., M.P., F.R.S., F.G.S.†

THROUGH the kindness of Lord Northampton and Mr. Pratt I have had an opportunity of examining several specimens of fossil fish found with the beautiful *Ammonites* and *Belemnites* already described by Mr. Pratt and Professor Owen, in the Oxford clay, at Christian Malford, near Chippenham. Some of these ichthyolites are in an excellent state of preservation; others are mere fragments. Those genera I have been able to identify belong to the *Lepidoid* and *Sauroid* families of the *Ganoid* order of Agassiz, viz. *Lepidotus*, *Leptolepis*, and *Aspidorhynchus*. These three genera

* In the accompanying plate, fig. 1. represents this fossil of its natural size, and fig. 2. is a magnified view of part of the jaw.

are found also associated with Ammonites and Belemnites in the lithographic stone quarries of Germany. The species appear all to be new.

GANOID ORDER.

Lepidoid Family.

Lepidotus macrochirus, Eg.

I have only seen one specimen referable to the genus *Lepidotus*; it is, however, the finest ichthyolite yet discovered in this locality. The fish reclines on its back, and presents the whole ventral surface to the spectator. The head bones are rather dislocated, by which accident an advantageous view of the teeth is obtained. The two large bones of the horns of the hyoid bone are seen *in situ*. The pectoral and ventral fins are well displayed; the anal and caudal are crushed and indistinct. As compared with the species of this genus already described by Agassiz, this *Lepidotus* has the nearest affinity to *Lepidotus semiserratus* of the Whitby lias: it differs in the narrowness of the head, the larger size of the pectoral fins, and the marginal armature of the scales. The form of the lower jaw is well shown. The teeth are numerous, both in the upper and lower jaws, as also on the palate; they are in the form of acute cones, on constricted pedicles. The teeth on the palate are larger than those on the maxillary bones. The pectoral fins are large and strong. The rays are twenty or twenty-one in each fin, single for about half their length, then articulated; the articulations being frequent, and the ossicles small. The rays dichotomize so frequently as they recede from the base, that the extremity of the fin has a finely fimbriated appearance. The ventral fins are small, but the rays composing them are strong, apparently about eight in number. The scales have the thick enamelled surface so characteristic of the genus. The posterior edges of the flank scales are deeply notched or scalloped; this feature is traceable in other parts, although the number of notches in the caudal region is reduced to two or three. The gradual change of outline from the oblong to the lozenge shape as the scales approach the belly and tail, obtains as in other species of this genus. The arrangement of the scales of the vent has not hitherto been described in this genus. Indeed, no specimen with which I am acquainted, exhibits these details; and yet we can scarcely imagine them peculiar to the species under description, but as common to the genus. In front of the anal fin, we find a pair of scales of large size; these are overlapped by a single scale considerably larger, and the anal orifice is situate under the middle of the posterior edge of the latter, coincident with the line of junction between the former. These three scales are quadrangular, and deeply notched on their free margin. Having had only a brief opportunity of examining the specimen above described, the details are not so complete as I could wish; they are, however, sufficient

to show that this *Lepidotus* of the Oxford clay is not referable to any of those species already described by Professor Agassiz.

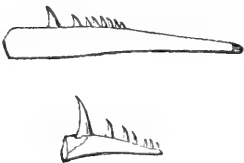
Sauroid Family.

Leptolepis macrophthalmus, Eg.

Lord Northampton possesses a specimen, nearly perfect, from the same locality as the preceding, referable to the Sauroid genus *Leptolepis*. It differs from the other numerous species of this genus in the long, slender, and superlatively elegant form of the body, as also by the large size of the orbit. The length of this fish is $5\frac{1}{2}$ inches, depth at the dorsal fin $\frac{9}{10}$ of an inch. The head is small, and its constituent bones thin and smooth. The mouth also is very small, and opens upwards; the orbit very large in proportion to the size of the head. The spinal column is composed of about 40 vertebræ, the terminal ones decreasing rapidly in size, and tending upwards: the ribs and vertebral spines are slender. The pectoral fins are composed of ten or twelve rays each; of these the anterior ones are strong. The ventral fins are comparatively large; they are situate nearly in the centre of the body, and have twelve rays in each. The dorsal fin is small, and immediately opposite the ventrals. The number of rays in this fin is not discernible. The anal fin is also small, and situate about half way between the ventral and caudal fins; the latter organ is symmetrical: the upper lobe has eight rays springing from the terminal vertebra, and has three or four fulcral rays on its upper margin. The lower lobe has from eight to ten rays. The scales are small and thin, finely sculptured with concentric striæ, as in *Leptolepis dubius*, and other species of this genus. This fish appears not uncommon in the Christian Malford deposit, as I have seen several specimens in the collections of Lord Northampton and Mr. Pratt, to whose liberality I am indebted for the specimens in my own cabinet. The latter gentleman has also presented me with two specimens which appear to constitute another species; they are not, however, sufficiently perfect to enable me to separate them definitively from the species already described, and the most striking differences appear to be, the greater size of the fish, and the stronger proportions of the ribs. The opercular bones are large, and the pre-operculum is sculptured with shallow radiating grooves. The fins are indistinct or wanting in these specimens; and the scales are wholly absent. I designate this fish by the provisional appellation of *Leptolepis costalis*.

Aspidorhynchus euodus, Eg.

The evidence of the occurrence of this remarkable genus, associated with the forms described above, consists of a few detached scales, and two fragments of jaw, one belonging to Lord Northampton, and the other to Lord Enniskillen. The scales present the peculiar characters found in the other species of the genus, and



leave no doubt as to the correctness of the generic identification. The teeth differ so far from the continental specimens as to indicate a distinct species. The jaw is furnished, as in the recent *Lepidosteus*, with teeth of various sizes, the larger ones projecting at intervals, the smaller ones filling the spaces between the principal ones. These teeth are remarkable for their strength and falcate shape. The bases are broad, and as the shafts taper to the apices they incline gently backwards: the result of this arrangement is a most formidable array of prehensile weapons, well adapted to secure the prey of these destructive fish, notwithstanding the obstruction of the ganoid scales with which they were invested. The specimens as yet brought to light of this fish are insufficient to show any further details of the species; it is to be hoped, however, that ere long, the riches of the Christian Malford deposit will be more fully explored. As far as our information extends, the association of forms there found is a natural one. The strong conical grinders of the *Lepidotus* are fully equal to contend with the shells of the *Ammonites* and the *Mollusca*, the sharp bristling teeth of the *Lepidolepis* would find a suitable prey in the soft parts of the *Belemnites*, while they in their turn would find it difficult to elude the swift course and murderous jaws of the *Aspidorhynchus*.

4. On certain *Calcareo-corneous Bodies found in the outer chambers of AMMONITES.* By H. E. STRICKLAND, M.A., F.G.S.



a. A portion of the broken shell of an Ammonite, with the calcareo-corneous body in situ, reduced to one-fourth natural size.

b. The body in (*a*), of the natural size.

c. Another similar body of a different species, also of the natural size.

In 1841, Miss Anning, of Lyme Regis, drew my attention to some black-coloured substances which she had occasionally met with in the interior of the *Ammonites Bucklandi*, and which she considered to indicate the presence of an ink-bag in the animal of the Ammonite, corresponding to that of the *Sepiæ*. From these and other specimens, it appeared to me evident that these substances had constituted, not an ink bag, but a laminar appendage to the animal, adapted to discharge some unascertained function. The specimens

presented the appearance of a very thin concave shell, glossy on its outer surface, with irregular concentric undulations, crossed by longitudinal striæ and fine irregular oblique wrinkles. In the middle of the external margin is a large undulation or sinus. The inner surface, as exhibited by its cast, is of a dull black, the outer surface of the shell being of the colour of horn. Miss Anning informed me that these bodies generally occur about the middle of the outer chamber of the ammonite, whence they are obtained by breaking the fossil; but as this process more frequently destroyed than exposed the object of search, I was unable, during my stay at Lyme Regis, to procure any tolerably perfect specimens, or to arrive at any satisfactory conclusion as to their nature.

In 1843, my attention was again called to the subject by finding in a bed of lias limestone, at Temple Grafton and Bickmarsh, near Bidford, in Warwickshire, (a bed remarkable for the variety of fish, plants, insects, and Crustacea which it contains,) several anomalous bodies whose characters were difficult to define. These substances are of a nearly semicircular form, very thin, slightly concave, presenting a small notch at the middle of the straight side, and having their surface covered with irregularly wrinkled lines of growth, concentric to the notch above mentioned. From the same point of departure also proceed fine radiating lines, visible only with the help of a lens. The colour is usually black, but they sometimes present a browner tint, as if from a mixture of calcareous and carbonaceous matter. The usual diameter is from half to five-eighths of an inch. (See figure *c*.)

In speculating on the nature of these bodies, although the black colour seemed to indicate a vegetable origin, yet the concentric lines of growth appeared so evidently allied to the structure of Molluscous shells, that I could not hesitate to seek for their affinities among the latter class of animals. Indeed, the general aspect is so much like that of an *Orthis*, that had they been found in a Palæozoic rock, I should probably have referred them to the *Brachiopoda*. But on closer examination it was evident, that these bodies were very little, if at all, calcareous, and that though their mode of growth was similar to that of shells, yet their composition was, in great measure, corneous, and probably elastic, like the plate in the genus *Laplysia*. It seemed, therefore, likely that they were part of the internal organisation of some mollusc, and on comparing them with the bodies before mentioned, as occurring in the Ammonites of Lyme Regis, it seemed not improbable that they were of a similar nature. Now the bed of lias in which these substances occur, contains two species of Ammonites, the *A. planorbis*, Sow., and another allied to *A. Conybeari*; and the dimensions of these Ammonites are such as would very well permit the bodies in question to be contained in their outer chamber. The form, too, of the bodies, is nearly that of a transverse section of the chamber of the Ammonite, so that they might easily close it in the manner of an operculum. From these considerations, the most probable supposition seemed to be, that the

detached substances in the Bidford lias were portions of the animals of the Ammonites which occur in the same stratum.

This conjecture has been recently verified by finding a very interesting specimen. It is a species of Ammonite, allied to *A. Turneri*, Sow., but, as yet, I believe, unnamed, which occurs in a bed of clay, at Defford, Worcestershire, near the middle region of the lower lias. By a fortunate fracture, this specimen exhibits, embedded in the stone which fills the outer chamber, a substance evidently identical in its nature with those just described. It lies with the convex surface outwards, and the straight side turned towards the mouth of the shell. The portion exposed to view is the cast of the interior surface, which is somewhat irregularly waved, but exhibits distinct concentric lines of growth. The whole of this inner surface is black like the Bidford specimens, but portions of the substance itself, which still adhere to the cast, are white and calcareous, showing that in this species, at least, the body was of a shelly nature. The slight portions which remain of the outer surface of this thin calcareous plate exhibit fine lines, radiating rather irregularly from the centre of the straight side, in which there is a very small but deep emargination or notch. (See the figure *b*.)

Judging from the specimens thus repeatedly obtained within the outer chamber of several species of Ammonite, there can be no reasonable doubt that these bodies were appendages of the Cephalopodous mollusc which inhabited those shells. I leave it to more expert comparative anatomists to pronounce as to the precise nature of these corneo-calcareous appendages, which were possibly the representatives of the horny girdle described by Professor Owen as occurring in the recent nautilus, and which aids in the attachment of the animal to the shell. They may also possibly be the equivalents of that "ligamento-muscular disc," which protects the head of the recent nautilus.

These singular bodies may perhaps throw light on the nature of that much-disputed fossil the Trigonellites or Aptychus. I am aware that Professor Forbes has recently seen some reason for referring the latter fossil to the existing Holothuriadæ. But as this supposed affinity is as yet far from being demonstrated, I may be allowed to remark that the two valves of Trigonellites, when expanded, closely resemble in appearance the univalve disc which I have been describing; and when we recollect that Trigonellites have hitherto only been found in formations which also contain Ammonites, and that they have in several instances been found in the interior of Ammonites precisely as in the case of the bodies before us, there is, I think, a fair presumption that these singular bodies are allied in origin and in function to the remarkable fossils here described.

On referring to a paper communicated by M. Voltz to the Natural History Society of Strasburg, which will be found in the *Mem. de l'Institut* for 1837, p. 48, it appears that he was acquainted with fossils similar to those before us, and that he also

considered them to be allied to *Trigonellites* or *Aptychus*. He divides the Aptychi into three groups, *A. cornei*, *imbricati*, and *cellulosi*, the former of which differs from the two latter (which are *calcareous* and *bivalve*,) in being *corneous* and *univalve*, both which characters are applicable to the fossils which I have above described. He supposes that in the corneous species a certain degree of motion was effected in the two halves of the body by means of its own elasticity, while in the calcareous groups the same end was obtained by means of a bivalve structure. He enumerates five species of the corneous group, all of which are from the lias and inferior oolite, and which, like the imbricate and cellulous species, are occasionally found in the interior of Ammonites, occupying a symmetrical position, and corresponding in their dimensions to the shell in which they are found. From these and other reasons, M. Voltz regards the whole of this group of fossils as appendages to the animals of Ammonites, a view which is confirmed by the facts adduced in the present communication.

5. Notice concerning the Tertiary Deposits in the south of Spain.

By JAMES SMITH, Esq., of Jordanhill, F.G.S.

IN the bay of Gibraltar, immediately to the north of the plain which separates the fortress from the Spanish territory, we meet with a series of low swelling hills of yellow rubbly sandstone, the beds dipping to the S.W. at an angle of 12° , and abounding in marine tertiary fossils. Of these fossils, there is only a small variety, and of many of the species I could only find casts; but these were sufficient to furnish an important link, connecting distant deposits; for upon comparing them with the specimens in the Society's Museum, illustrative of Col. Silvertop's account of the tertiary formation of Murcia and Grenada, and Lieut. Spratt's paper on the Geology of Malta, I find that the three deposits are identical.

I have also observed tertiary beds at Cadiz, and between Xeres and Seville, which, I am satisfied, belong to the same deposit; and Mr. Sharpe, in his paper on the Geology of Lisbon, has assigned reasons, with which I entirely agree, for considering that the tertiary beds of the Tagus coincide with those of the south of Spain.*

In a communication respecting the age of the Lisbon tertiary beds, I stated the grounds which led me to conclude that it was nearly the same as that of the Bourdeaux deposit, and I may now add, that I consider it more ancient than the Touraine Faluns, or older crag.† It will be seen, from the report of Professor

* Geol. Transactions, 2d series, vol. vi. p. 113.

† Geol. Proceedings, vol. iii. p. 492.

Forbes on the Malta fossils*, that he has arrived at the same conclusion with respect to their age.

Professor Agassiz, who examined my collection of Lisbon shells, considered that they were of the same age as the Molasse of Switzerland.

The whole of these deposits, therefore, may be placed in the Miocene or middle division of the tertiary system; a formation of prodigious extent, which appears to have comprehended the whole of the southern portion of the European continent, from the shores of Portugal to the Morea, and from Switzerland and Vienna to Malta and the Straits of Gibraltar.

* Geol. Proceedings, vol. iv. p. 232.

II. CATALOGUE

OF

LOWER GREENSAND FOSSILS,

IN THE MUSEUM OF THE GEOLOGICAL SOCIETY,

WITH NOTICES OF SPECIES NEW TO BRITAIN, CONTAINED IN OTHER
COLLECTIONS. BY PROFESSOR EDWARD FORBES, F.R.S.*

[In the following list, after the name of the founder of the species, the best figure in a British work, or if there be none, in a foreign work, is quoted. Wherever there is a possibility of doubt, a note of interrogation is affixed. The localities quoted are those from which there are specimens in the collection. Other localities are given between brackets. The donors' names will be given in a list at the termination of the catalogue.]

MOLLUSCA.

Acephala Lamellibranchiata.

1. *Teredo*. Sp.
Loc. Hythe.
2. *Gastrochæna*. Sp. (an *Gastrochæna dilatata Deshayes* in Leymerie, t. v. pl. 3. f. 1.?)
Loc. Faringdon, Atherfield, Hythe, Peasemmarsh.
3. *Pholas?* *priscus* Sowerby, Min. Conch. t. 581.
Loc. Hythe, Maidstone.
4. *Solecurtus Warburtoni*. Sp. nov. Pl. 2. f. 1.
S. testâ elongato-oblongâ, depressâ, concentricè striatâ, posticè subexpansâ, anticè striis subtilissimis ex umbone *radiantibus*, umbonibus submedianis.
Lon. $0\frac{8}{12}$ unc. Lat. $2\frac{8}{12}$ unc. †
Loc. Atherfield (Cracker bed).

This species, which bears a distant resemblance to the living *S. coarctatus*, presents some remarkable characters. The shell is depressed, nearly æquilateral, and is rather broader at one extremity than at the other. The surface is finely striated by lines of growth, which are crossed at the anterior and narrower extremity by regular very minute radiating striæ, obscure traces of which are seen also on other parts of the shell. In a large specimen the striæ are replaced in the centre by smooth longitudinal

* This Catalogue is referred to, and the general result given, in the previous number of the Geological Journal, p. 78.

† In the measurements of bivalves in this list, by length is understood the distance between the cardinal and anterior margins; by breadth, the transverse measurement parallel to those margins.

rays, separated by strongly marked lines of growth, thus presenting a scalariform appearance. These markings become obsolete, and towards the broader extremity disappear altogether.

VAR.? There is a young *Solen* in the collection from the same locality, which appears to be a variety differing in the more ex-centric position of the beaks. Its surface is not sufficiently perfect to present the characteristic markings.

NOTE. The cast described and figured by M. A. D'Orbigny as *Solen Robinaldinus*, from the Neocomian of France, and that called *Solen compressus* by Goldfuss, may be related to this species.

5. *Panopæa mandibula* (Mya sp.) Sow. M. C. t. 43.

Loc. Atherfield, Hythe, Reigate.

Var. β . *obliqua*. *P. obliqua* D'Orb. T. C. pl. 352.

Loc. Atherfield.

6. *Panopæa plicata* (Mya sp.).

Var. α . Sow. M. C. t. 419. fig. 3.

Var. β . *Pholadomya Prevosti* Desh. in Leym. pl. 2. f. 7.

Var. γ . *Pholadomya acutisulcata* Desh. in Leym. pl. 3. f. 2.?

Loc. Atherfield, Culver, Hythe, Reigate, Sandgate, Stopham.

NOTE. A very variable species, common to the upper and lower greensands.

7. *Panopæa elongata* (Mya sp.) Römer. Cret. Geb. t. x. f. 5.?

Loc. Hythe, Pulborough.

NOTE. Possibly only an elongated variety of the last.

8. *Panopæa neocomiensis* (Pholadomya sp.) Leym. pl. 3. f. 4.

Loc. Atherfield.

NOTE. The surface of this species is strongly granulated; the granulations are arranged in lines. Identified by comparison with French specimens.

9. *Panopæa*?

Apparently a distinct species, but not sufficiently perfect for certain determination. It is nearly æquilateral.

Loc. Redhill, Reigate.

10. *Pholadomya gigantea* (Pholas sp.) Sow. in Geol. Trans. 2d ser. vol. iv. pl. 14. f. 1.

Loc. Court-at-Street.

11. *Pholadomya Martini*. Sp. nov. Pl. 2. f. 3.

P. Testâ obliquâ, tumidâ, valde inæquilaterali, costis tuberculatis radiantibus ornatâ, sulcis transversalibus decussantibus; costis posterioribus approximatis, anterioribus distantibus.

Lon. $0\frac{1}{2}$ unc. Lat. $2\frac{8}{12}$ unc.

This species is common at Atherfield. It rarely attains larger dimensions than those noted. It is almost always tumid and oblique, with numerous longitudinal ribs, which are more or less tuberculated by the intersection of lines of growth. These ribs are widely set at the buccal extremity, and more distant at the anal. In the *Pholadomya gigantea*, the ribs are most numerous at the buccal end, and the shell is much broader.

Loc. Pulborough, Atherfield.

12. *Pholadomya? Agassizi* D'Orb. T. C. pl. 363. f. 1—3? (*Goniomya caudata* Agassiz.)
A fragment. Loc. Hythe.

13. *Corbula striatula* Sow. M. C. t. 572. f. 2, 3.
Loc. Atherfield, Peasemars, Hythe, Ingoldsthorpe, Maidstone.

14. *Tellina inæqualis* Sow. M. C. t. 456. f. 2.?
Loc. (Casts.) Parham, Atherfield.

15. *Tellina? angulata* Desh. in Leym. t. 5. pl. 3.?
Loc. (Cast.) Peasemars.

16. *Tellina? vectiana*. Sp. nov. Pl. 2. f. 2.
T. testâ oblongâ, depressâ, subinæquilaterali, transversè striatâ, striis regularibus, numerosis, posticè rotundatâ, anticè cuneatâ, angulatâ, carinatâ.

Lon. $0\frac{1}{2}$ unc. Lat. $0\frac{1}{2}$ unc.

Shell oblong, depressed, regularly and deeply striated transversely, rounded posteriorly, and angulated anteriorly, where a strong carination runs from the beak to the pointed extremity, over which the striæ pass and become slightly lamellated in the larger specimens. Young shells have much the aspect of Venus.

Loc. In the Cracker bed at Atherfield, not uncommon.

17. *Corbis corrugata* (*Sphæra* sp.) Sowerby, M. C. t. 335.

SYN. *Venus cordiformis* Deshayes. *Corbis cordiformis* D'Orb.
Cardium galloprovinciale Matheron. (according to D'Orbigny.)

Loc. Atherfield.

NOTE. The hinge of this shell being now known, the genus *Sphæra* must be suppressed, and the species on which it was founded placed in the genus *Corbis*. This was first shown by M. d'Orbigny, and a well-preserved hinge in the Society's collection confirms his view. British specimens were identified by that palæontologist with the French *Corbis cordiformis*.

18. *Corbis? fibrosa*. Sp. nov.

C? testâ transversè ovatâ, depressâ, transversè sulcato-striatâ, interstitiis longitudinaliter crenatis.

Lon. $0\frac{1}{2}$ unc. Lat. $0\frac{2}{2}$ unc.

I have applied this name provisionally to a species found at Reigate, Peasemars, and Atherfield, but of which the specimens are very imperfect, and not sufficient for the determination of their true generic position.

19. *Lucina? solidula*. Sp. nov. Pl. 2. f. 7.

L. testâ convexâ, suborbiculari, æquilaterali, concentricè striatâ, striis regularibus; umbonibus prominentibus.

Lon. $0\frac{8}{2}$ unc. Lat. nearly the same.

Shell nearly orbicular and convex, regularly striated by lines of growth, apparently very constant in form; it is nearly allied to the next species, and differs in being less globose and broader towards the beaks. An *Lucina Dupiniana* D'Orbigny?

Loc. Atherfield, Redhill, Peasemars.

20. *Lucina globiformis* Leymerie, pl. 3. f. 8. a, b, c.?

Loc. Atherfield. The specimens agree well with the figures in Leymerie.

21. *Cyprina angulata* (Venus sp.) Sow. M. C. t. 65.

Var. β rostrata. *C. rostrata* Sow. in Fitton, G. T. n. s. vol. iv. pl. xvii. f. 1.

Loc. Atherfield, Peasemars, Hythe, Reigate, Shorncliff.

NOTE. Both varieties are common at Atherfield, where the species is found of a large size.

22. *Venus?* (*Cytherea?*) *parva* Sow. M. C. t. 518.

Loc. Atherfield, Peasemars, Hythe, Parham.

23. *Venus* [*Artemis?*] *caperata* Sow. M. C. t. 518. f. 1.

Loc. Pulborough. (Casts.)

24. *Venus* [*Pullastra?*] *ovalis* Sow. M. C. t. 567. f. 1, 2.

Loc. Atherfield.

Var. β *elongata* (an *Venus Brongniartina* Leym. pl. 5. f. 7.?)

Loc. Atherfield, Peasemars.

25. *Venus Orbigniana*. Sp. nov. Pl. 2. f. 5.

V. testâ rotundatâ, convexâ, lævigatâ, umbonibus obtusissimis.

Lon. $0\frac{7}{12}$; lat. $0\frac{8}{12}$ unc.

Allied to *Venus parva*, but easily distinguished by its very obtuse beaks, and smooth surface.

Loc. Abundant in the Cracker beds at Atherfield.

26. *Venus vectensis*. Sp. nov. Pl. 2. f. 4.

V. testâ orbiculari, convexâ, concentricè sulcato-striatâ, umbonibus parvis.

Lon. $1\frac{3}{12}$; lat. $1\frac{5}{12}$ unc.

This shell resembles in form *Artemis exoleta*. It is very regular, rounded and convex, smooth towards the beak, or obsoletely striated concentrically, furrowed towards the margin, and marked at intervals by deeper sulcations. The shell is thin, and the margin appears to be smooth.

Loc. In the Cracker bed at Atherfield. (In Dr. Fitton's cabinet.)

27. *Venus?* *fenestrata*. Sp. nov. (Austen MSS.) Pl. 2. fig. 6.

V? testâ oblongâ, subdepressâ, valde inæquilaterali, costis tenuibus distantibus concentricis ornatâ, interspatiis fortè longitudinaliter sulcatis; lunulâ parvâ.

Lon. $0\frac{6}{12}$; lat. $0\frac{9}{12}$ unc.

Shell ovate or oblong, depressed, much produced anteriorly, and subtruncate; ornamented by regular lamellar transverse ribs, which are angulated towards the anterior extremity. These ribs

are distant, and on a perfect specimen half an inch in breadth, are ten in number. The furrows between them are traversed by numerous regular raised radiating ribs, so as to give the shell a fenestrated aspect.

Loc. Peasemarsch.

NOTE. Allied to the *Astarte* (*Venus*?) *multistriata* of Blackdown. The strong radiating striæ and the almost lateral position of the beak, are excellent distinguishing characters.

28. *Venus* ? [*striato-costata*].

V. ? testâ oblongâ, triangulari, inæquilaterali, plus minusve depressâ, costis elevatis, reflexis, distantibus, concentricis ornatâ, interspatiis transversè striatis, interstitiis striarum longitudinaliter minutissime striatis, lunulâ excavatâ.

Lon. $0\frac{5}{4}$; lat. $0\frac{3}{12}$ unc.

Shell more or less rounded, triangular or oblong, sometimes much depressed, sometimes almost inflated, regularly ribbed transversely, ribs usually 7—9; the ribs are acute and reflexed, the interspaces regularly furrowed transversely, and finely striated longitudinally. The anterior extremity is usually produced and truncated, the posterior very short. In general aspect it comes near *Astarte* (*Venus*?) *formosa* of the Blackdown beds, but differs in form, convexity, and number of ribs, the more prominent of which are more numerous and closer set in the Blackdown species.

NOTE. This shell and the last appear to me to be more nearly allied to certain species of *Venus* (as *Venus fasciata* of Montagu) than to any known *Astartes*. Specimens of this species were sent to M. d'Orbigny, who identified them with his *Astarte numismalis*. If so, his figure and description of that shell do not notice the peculiar characters of the interspaces of the ribs. It resembles much more nearly his *A. striato-costata*, and is probably identical with that species. I have accordingly retained that specific name provisionally, in preference to running the risk of creating a useless synonym.

There are casts of apparently several other species of *Venus* in the Society's collection, but too imperfect to determine.

29. *Crassatella Robinaldina* D'Orb. T. C. pl. 264. p. 10—13.

Specimens of this remarkable shell, easily distinguished by the angulated diverging ribs of its surface*, are in the collections of Mrs. Smith of Tunbridge Wells (from Maidstone) and of Mr. Hills of Chichester (from Court-on-street). Identified by comparison with French specimens.

30. *Astarte obovata* Sow. M. C. t. 353.

Var. *a*. Margin crenulated. *Astarte transversa* Leym. pl. 5. f. 5. ? Certainly *Astarte transversa* of D'Orbigny, T. C. pl. 261.

Loc. Hythe.

* We have a similar style of ribbing in the recent *Crassatella Tellinoides*, a species inhabiting the coasts of Massachusetts

Var. β . Margin plain. *Astarte Beaumontii* Leym. pl. 4. f. 1. a, b. (compared and identified with French specimens).

Loc. Culver (Atherfield, Sandown, Hythe, Peasemarsch).

31. *Astarte substriata* Leym. pl. 6. f. 3. (and var. *A. illunata*, pl. 6. fig. 2.)

Loc. Reigate, Peasemarsch, Atherfield.

32. *Cardita neocomiensis* D'Orb. T. C. pl. 267. f. 1—5. ?

Loc. Maidstone.

Var. β . inflata — *Cardita quadrata* D'Orb. pl. 267. p. 6—9. ?

Loc. Maidstone.

The specimens agree well with the figures and descriptions of M. d'Orbigny.

33. *Thetis Sowerbii* Roëmer.

Var. α . minor — *Thetis minor* Sow. M. C. t. 513. figs. 5, 6.

Var. β . major — *Thetis major* Sow. M. C. t. 513. f. 1—4.

Loc. Atherfield, Hythe, Peasemarsch, Parham.

NOTE. Distorted specimens often resemble *Isocardia*.

34. *Cypricardia? undulata*. Sp. nov. Pl. 3. f. 1.

C. ? testâ transversè oblongâ, depressâ, carinatâ, valdè inæquilaterali, latere antico brevissimo, rotundato, latere postico expanso, truncato, carinato, transversè sulcato, sulcis regularibus, distantibus, ad carinam interruptis, reliquâ testâ transversè striatâ, striis minutis regularibus, umbonibus sub-marginalibus.

Lon. max. $0\frac{6}{12}$; lat. $1\frac{4}{12}$ unc.

The form of this shell resembles most nearly that of some recent *Cypricardia*. It is oblong, depressed, with almost marginal beaks, and has the larger side greatly produced and expanded. The shorter extremity is rounded and narrow, the other broad and truncate. From the beaks to the anterior angle of the truncated extremity runs a keel dividing the shell into two nearly equal parts. The posterior division is deeply and distantly sulcated, but otherwise smooth; the anterior wants the sulcations, but is marked with very fine and regular transverse striæ.

Loc. Atherfield.

35. *Isocardia? ornata*. Sp. nov. Pl. 2. f. 10.

I. ? testâ longitudinaliter ovatâ, angulatâ, inflatâ, bicarinatâ, posticè truncatâ, transversè sulcato-striatâ, inter carinas striis minutis obliquis angulatis ornatâ (nucleo lævigato).

Lon. $0\frac{9}{12}$; Lat. $0\frac{7}{12}$ unc.

Shell much inflated, oblique and somewhat triangular, longer than broad; two keels run divergingly from the beak to the margin, the longer bounding the abrupt truncation of the posterior

extremity. The anterior side is not nearly so truncate. Between the keels the surface is elegantly marked by oblique striæ, angulated in the centre; the angle directed forwards. Beyond the keels on each side there appear to be no striæ, but transverse sulcations of growth, which are strongest on the truncated side. The beak is small and incurved. The cast is smooth.

Loc. Atherfield. The peculiar markings of this shell distinguish it from all other known species.

36. *Cardium Cornuelianum* D'Orb. T. C. pl. 256. f. 1, 2.

Loc. Atherfield, Peasemarsch.

NOTE. Identified with French specimens.

37. *Cardium subhillanum* Leym. pl. 7. f. 2. a, b.

Loc. Atherfield, Hythe.

NOTE. Confounded with *Cardium striatulum* of the Mineral Conchology, in the list of fossils appended to Dr. Fitton's Memoir in the Geol. Trans., 2d ser. vol. iv.

38. *Cardium peregrinosum* D'Orb. T. C. pl. 239. f. 1, 2, 3.

Loc. Atherfield.

39. *Cardium sphæroideum*. Sp. nov. Pl. 2. f. 8.

C. testâ longitudinaliter oblongâ, subquadratâ, tumidâ, tertiâ parte regulariter transversè sulcatâ, sulcis numerosis; latere anali sublævigato, à parte sulcatâ sulco longitudinali diviso.

Lon. $3\frac{1}{12}$; lat. $2\frac{9}{12}$ unc.

Shell inflated, rather oblong and angulated posteriorly. The surface is marked by deep and regular transverse sulcations, which are cut off from the somewhat truncated anal side by a deep longitudinal furrow. The sulcations on a specimen of the above dimensions are about eighty in number. The shell is thick, especially at the margins. The beak is very prominent. The cast is smooth.

Loc. Culver, Hythe, Sandgate.

NOTE. The cast of this shell appears to have caused the insertion of *Cardium dissimile* in the list of lower greensand fossils appended to Dr. Fitton's Memoir in the Geological Transactions, 4th vol. 2d ser.

40. *Cardium imbricatorium* (*Lucina* sp.) Desh. in Leym. pl. 4. f. 2.

Loc. Atherfield, Parham, Hythe.

NOTE. I insert this species as a *Cardium*, on the authority of M. A. d'Orbigny. The British specimens have been identified by comparison with the French.

41. *Cardium Ibbetsoni*. Sp. nov. Pl. 2. f. 9.

C. testâ suborbiculari, subglobosâ, posticè subtruncatâ, longitudinaliter costatâ; costis numerosissimis, minutis, planis, squamis transversis minutissimis gerentibus. (Nucleo lævi.)

Lon. $0\frac{4}{12}$; lat. $0\frac{9}{24}$ unc.

This little *Cardium* is more or less rounded in outline, nearly æquilateral and inflated. The surface is marked by very fine longitudinal ribs, so small that the lens is required in order to see them distinctly. On these ribs are very minute transverse squamæ. The margin is denticulated by the ribs, and the beaks are more or less acute and prominent. The cast is quite smooth.

Loc. Common in the Cracker bed at Atherfield.

42. *Cardium Benstedii*. Sp. nov.

I have applied this name to a small suborbicular, subdepressed, longitudinally ribbed *Cardium* found at Maidstone by Mr. Bensted. It is very distinct from any other Lower Greensand species, but better specimens are required before it can be figured.

43. *Cardium* [*Hemicardium*]? *Austeni*. Sp. nov. Pl. 3. f. 3.

C. testâ lanceolatâ, valde obliquâ, carinatâ, latere anali truncatâ longitudinaliter striatâ; striis in parte anali profundioribus, reliquâ testâ obsoletis; umbonibus prominentibus incurvis, submarginalibus.

Lon. $0\frac{9}{12}$; Lat. $1\frac{1}{2}$ unc.

This remarkable and beautiful fossil, which I have provisionally placed in the subgenus *Hemicardium* of the genus *Cardium*, is very oblique, convex, and sharply carinated obliquely, with recurved submarginal beaks. The surface is marked by very fine longitudinal ribs, which in some specimens appear to be alternately larger and smaller. The carination bounding the abruptly truncated side is formed by one of these ribs, more prominent than the rest.

Loc. Peasemars, Atherfield.

44. *Trigonia caudata* Agassiz. (D'Orb. T. C. pl. 287.) *Trigonia scabra* of British authors, not of Lamarek.

Loc. Atherfield, Peasemars, Hythe, Shanklin.

45. *Trigonia carinata* Agassiz. (T. harpa Desh. in Leym. pl. 9. f. 7.)

Loc. Hythe, Culver.

46. *Trigonia aliformis* Parkinson. (Sow. M. C. t. 44.)

Loc. Atherfield, Parham, Shanklin, Sandgate.

47. *Trigonia spinosa* Parkinson. (Sow. M. C. t. 86.)

SYN. *T. ornata* of D'Orbigny. Identified by a comparison of specimens.

Loc. Sellinge, Maidstone.

48. *Trigonia dædalea* Parkinson. (Sow. M. C. t. 88.)

Loc. Atherfield, Reigate.

NOTE. Specimens sent to M. d'Orbigny were identified by him with the *Trigonia rudis* of the Palæontologie Française.

49. *Trigonia nodosa*. (Sow. M. C. t. 507.)

Loc. Hythe.

50. *Nucula scapha* D'Orbigny, T. C. pl. 301. f. 1, 2.

Loc. Hythe, Atherfield.

NOTE. Identified by M. d'Orbigny. The surfaces of our specimens are transversely striated. The striae are very minute, and are not represented in the figures of the French shell.

51. *Nucula spathulata*. Sp. nov. Pl. 3. f. 4.

N. testâ depressâ, transversè lineari-lanceolatâ, valde in-æquilaterali, striatâ, striis transversis minutissimis, anticè longe-rostratâ, rostro angusto, extremitate rotundato, posticè rotundatâ, angulo cardinali obsoleto.

Lat. $0\frac{7}{12}$; Lon. $0\frac{3}{12}$; Lon. rost. $\frac{5}{12}$ unc.

A well-marked, spoon-shaped *Nucula*, much depressed, very in-æquilateral and produced into a long narrow rostrum which has the extremity rounded, and is not at all carinated. Under the lens the surface is seen to be very finely striated transversely.

Loc. Atherfield.

52. *Nucula antiquata* Sow. M. C. t. 475. f. 4.

Loc. Parham. (Casts.)

53. *Nucula impressa* Sow. M. C. t. 475. f. 3.

! Loc. Parham, Atherfield.

54. *Nucula obtusa* Sow. in Fitton, G. T., 2d ser. vol. iv. t. 17. f. 11.? (*Nucula planata* Desh. in Leym. according to D'Orbigny.)

Loc. Atherfield.

55. *Arca exaltata* Nilson? (Goldfuss, pl. 122. f. 1 *a, b*. D'Orbigny, testa junior, T. C., pl. 308. f. 4, 5.) Pl. 3. f. 5.

SYN. *Arca Gabrielis* Leym. (identified by M. D'Orbigny.)

Loc. Atherfield, Culver.

56. *Arca Raulini* (*Cucullæa* sp.) Leymerie, pl. 10. f. 1 *a, b*.

a. ribs on anterior extremity slightly developed or obsolete.

Arca Raulini D'Orb. T. C. pl. 310. f. 1—3.

β. ribs on anterior extremity, strongly marked. (*A. Neocomiensis* D'Orb. T. C. pl. 310. f. 6. 8. ?)

γ. transverse striae strongly marked. *A. marullensis* D'Orb. T. C. pl. 310. f. 3. 5.

Loc. Peasemars, Pulborough, Earlstoke, Atherfield, Hythe. The form *β* is most common. *γ* is rare.

57. *Arca securis* (*Cucullæa* sp.) Leym. pl. 7. f. 6. (and 7.)

Loc. Atherfield. The British specimens belong to the variety "*A. major*" of M. Leymerie.

58. *Arca Dupiniana* D'Orb. T. C. pl. 310. f. 9, 10.

Loc. Peasemars. Excellently represented in the "Paleontologie Française."

59. *Arca Carteroni* D'Orb. T. C. pl. 309. f. 4.

Loc. Peasemars, Atherfield.

60. *Arca Cornueliana* D'Orb. T. C. pl. 311. f. 1, 2, 3.

Loc. Atherfield, Earlstoke, Pulborough, Hythe, Peasemars, Reigate.

NOTE. This species, which is very common in the Lower Greensand, has hitherto been confounded with the "*Cucullæa glabra*" of Parkinson and the Mineral Conchology, from Blackdown, which is certainly only the young of *Arca* (*Cucullæa*) *fibrosa*.

61. *Gervillia aviculoides* Sow. M. C. t. 511.

Loc. Atherfield, Pulborough.

Var. β . Valves very unequal. *Gervillia anceps* Desh. in Leym. pl. 10. f. 3.?

Loc. Peasemars.

62. *Gervillia solenoides* Defrance. (Sow. M. C. t. 510. f. 1—4.)

Loc. Shanklin.

63. *Gervillia linguloides*. Sp. nov. Pl. 3. f. 9.

G. testâ triangulari-lanceolatâ, obliquâ, alâtâ, carinatâ, concentricè substriatâ, margine cardinali recto, margine frontali abruptè truncato; umbonibus acutis, terminalibus.

Lon. $0\frac{5}{12}$; lat. $1\frac{1}{2}$ unc.

Shell triangularly lanceolate, very oblique, angularly carinate, with one side very abrupt and the other sloping, truncate at the extremity. Surface finely striated concentrically, or nearly smooth. Beaks terminal. Hinge resembling that of *Gervillia aviculoides*, the ligamental sulcations few and distant. A very remarkable shell resembling many *Aviculæ* in form.

Loc. Abundant and gregarious in the Cracker bed at Atherfield.

64. *Perna alæformis* Sow. M. C. t. 251.

Loc. Atherfield, Culver, Hythe.

NOTE. The young shell is marked with strong radiating ribs, and is apt to be mistaken for an *Avicula*.

65. *Perna Mulleti* Desh. in Leym. pl. 11. f. 1, 2, 3.

Loc. Peasemars, Reigate, Atherfield.

NOTE. On account of the importance of this fine species, figures of British specimens are given in Plate 1., showing it in a much more complete state than it has hitherto been represented. Fig. 1. is the exterior of the upper valve: f. 2. represents the hinge and interior: figs. 3. and 4. stages of growth.

66. *Avicula pectinata* Sow. in Fitton, G. T. 2d ser. t. iv. pl. 14. f. 3.

Loc. Ingoldsthorpe, Parham, Risborough, Folkstone.

67. *Avicula lanceolata*. Sp. nov. Pl. 3. f. 8.

A. testâ convexiusculâ, subtriangulari, lanceolatâ, transversè undulato-substriatâ, alâ obliquè abbreviatâ, margine cardinali recto, umbonibus excentricis.

Lon. max. $0\frac{7}{12}$; lat. $0\frac{8}{12}$ unc.

Shell very oblique, lanceolate and depressed, tumid near the excentric beaks, eared at both sides. The posterior auricle does not extend quite to the length of the shell, and is not so strongly separated from the body of the shell as the anterior. The hinge line is not quite straight. The surface of the shell is marked with undulated, more or less obsolete striæ; the cast is smooth.

Loc. Peasemars, Atherfield, Parham, Hythe.

68. *Avicula depressa*. Sp. nov. Pl. 3. f. 7.

A. testâ depressâ, latè triangulari, alatâ, transversè undulato-sulcatâ, alâ sinuatâ, margine cardinali recto, umbonibus terminalibus.

Lon. $0\frac{9}{12}$; lat. $0\frac{21}{24}$ unc.

A much depressed, broad, triangular shell, having the posterior auricle much developed and expanded, its edge being sinuated. The hinge margin is straight and the beaks are nearly terminal in consequence of the suppression or minute size of the anterior auricle. The surface is sulcated transversely, and the sulcations are undulate.

Loc. Atherfield.

69. *Avicula ephemera*. Sp. nov. Pl. 3. f. 6.

A. testâ depressâ, lanceolatâ, lævigatâ, alâ abbreviatâ, margine cardinali recto, umbonibus subterminalibus.

Lon. $0\frac{3}{12}$; lat. $0\frac{9}{24}$ unc.

A small, delicate, lanceolate, much depressed species, with the posterior auricle produced into a short wing, and the anterior one very small. The surface appears to have been smooth. The hinge margin is straight, and the beaks, in consequence of the form of the auricles, nearly terminal.

Loc. Atherfield.

70. *Inoceramus concentricus* Parkinson. (Sow. M. C. t. 305.)

Loc. Near Blackgang Chine, Isle of Wight. (In Dr. Fitton's collection.)

71. *Inoceramus*, a species allied to *Gryphoides*, but much depressed. Not sufficiently perfect for certain determination.

Loc. Pulborough.

72. *Pinna restituta* Hoeninghaus. (Goldfuss, pl. 138. f. 3.)

SYN. *Pinna tetragona* Sow. M. C. t. 313. f. 1. (referred by mistake to *P. tetragona* of Brocchi.) *Pinna Robinaldina* D'Orbigny (identified by M. d'Orbigny). *Pinna sulcifera* in Morris's Catalogue (by mistake, not *P. sulcifera* of Leymerie).

Loc. Peasemarsch, Atherfield.

73. *Mytilus lanceolatus* Sow. M. C. t. 439. f. 2.

VAR. *M. edentulus* Sow. M. C. t. 439. f. 1.

Loc. Hythe, Atherfield, Peasemarsch, Parham.

NOTE. *Mytilus tridens* and *prælongus* are both varieties of this species. (See G. T. 2d ser. vol. iv. p. 17.)

74. *Mytilus (Modiolus) asper*. (*Modiola aspera* Sow. M. C. t. 69. f. 4.)

SYN. *Modiola lineata*. G. T. 2d ser. vol. iv. pl. 14. f. 2.

Loc. Hythe, Maidstone.

75. *Mytilus (Modiolus) Carteroni* D'Orbigny, T. C. t. 337. f. 5, 6.

Loc. Peasemarsch.

76. *Mytilus (Modiolus) bellus (Modiola sp.)* Sow. in Fitton, G. T. 2d ser. vol. iv. pl. 11. f. 9.

SYN. *Mytilus Cornuelianus* D'Orb. T. C. pl. 337. f. 10—12.?

Loc. Atherfield, Maidstone.

77. *Mytilus (Modiolus) simplex (Modiola sp.)* Deshayes in Leymerie, pl. 7. f. 8.

Loc. Atherfield.

78. *Mytilus (Modiolus) æqualis (Modiola sp.)* Sowerby, M. C. t. 210. f. 2.

SYN. *Modiola Archiaci* and *M. bipartita* Leym.

Loc. Atherfield, Maidstone, Parham, Peasemarsch.

NOTE. A very variable species, both as to degree of lobation and of striation.

79. *Lithodomus? oblongus* D'Orb. T. C. pl. 344. f. 4—6.?

Loc. Atherfield, boring in the shells of *Gryphæa sinuata*.

80. *Lima semisulcata (Plagiostoma sp.)* Nilson. (Sow. G. T. 2d ser. vol. iv. t. 11. f. 10.)

Loc. Reigate, Parham.

81. *Lima elongata (Plagiostoma sp.)* Mantell. Sow. M. C. t. 559. f. 2.

SYN. *Modiola parallela*. M. C. t. 9. *Lima intercostata* Dujardin. *Lima carinata* Goldfuss.

Loc. Atherfield, Maidstone, Hythe.

82. *Lima undata* Desh. in Leym. pl. 8. f. 8.?

Loc. Maidstone; and from Atherfield in Dr. Fitton's collection.

83. *Lima expansa*. Sp. nov. Pl. 3. f. 11.

L. testâ latè ovatâ, convexiusculâ, expansâ, obliquâ, radiato-costatâ, costis tenuibus distantibus.

Lon. 1 unc. Lat. $0\frac{1}{2}\frac{5}{4}$ unc.

A broad, ovate, depressed shell, much expanded both above and below, oblique, the surface ornamented with fine distant longitudinal ribs.

Loc. Hythe.

84. *Lima lingua*. Sp. nov. Pl. 3. f. 10.

L. testâ elongatâ, convexiusculâ, subobliquâ (lateribus subparallelis), radiato-costatâ (costis numerosis tenuibus), transversèque striatâ.

Lon. $0\frac{8}{12}$ unc. Lat. $0\frac{9}{24}$ unc.

Nearly allied to the last, but more elongated and narrow; the surface ornamented with numerous fine longitudinal ribs crossed by transverse striæ. It bears a close resemblance to the recent *Lima tenera*.

Loc. Hythe.

85. *Pecten obliquus* Sow. M. C. t. 370. f. 2.

SYN. *P. interstriatus* Leym. pl. 13. f. 1. a, b.

Loc. Reigate, Atherfield, Culver, Peasemarsk.

86. *Pecten quinque-costatus* Sow. M. C. t. 56. f. 4—8.

Loc. Hythe, Peasemarsk, Maidstone, Atherfield, Shanklin.

87. *Pecten orbicularis* Sow. M. C. pl. 186.

Loc. Risborough, Sandgate, Atherfield, Culver.

88. *Pecten circularis* Goldfuss, t. 99. f. 10.??

Loc. Whale Chine, Isle of Wight.

NOTE. The specimen in the Geological Society's museum, which I have referred with doubt to the species of Goldfuss, is a thick shell allied to *P. orbicularis*, which it resembles in form, but differs in the production, sinuation, and sulcation of one of the auricles of one valve. The auricles are unequal in each valve. The surface is worn; but there are distinct concentric furrows and traces of fine regular ridges. It measures two inches and a half in length and the same in breadth.

Roëmer quotes this species from the corresponding strata of Hilsthon and Hilsconglomerat, but confounds it with *Pecten cinctus* of Sowerby, an oolitic form.

89. *Plicatula placunæa* Lamarek. (Leym. pl. 13. f. 2.)

Loc. Maidstone, Hythe, Atherfield.

90. *Hinnites Leymerii* Desh. in Leym. pl. 14. f. 1.
Loc. Atherfield.
91. *Ostrea carinata* Lamarck. (Sow. M. C. t. 365.)
Loc. Atherfield, Sandgate, Hythe.
92. *Ostrea prionota* Goldfuss. t. 74. f. 8.
Loc. Atherfield, Faringdon.
93. *Ostrea Leymerii* Leym. pl. 13. f. 4.
Loc. Atherfield.
94. *Gryphæa harpa* (*Exogyra* sp.) Goldfuss, t. 87. f. 7.
Var. β . (*Exogyra subplicata* Leym. pl. 11. f. 4, 5.)
Var. γ . *semiplicata*. Edge of undervalue sinuated and adhering to other shells by a great portion of its surface. Pl. 3. f. 12.
Loc. Atherfield.
95. *Gryphæa conica* (*Exogyra* sp.) Sow. M. C. t. 505.
Loc. Parham, Atherfield, Peasemars.
96. *Gryphæa sinuata* Sow. M. C. t. 336.
VARIETIES. — “*G. lævigata*” Sow. M. C. t. 605. f. 4.
 “*Exogyra subsinuata*” Leym.
 “*Exogyra Couloni*” of Swiss geologists.
Loc. Atherfield, Sandgate, Hythe, Boughton, Seabrook.
97. *Anomia convexa* Sow. in Fitton, G. T. 2d ser. vol. iv. pl. 14.
f. 7.
Loc. Redhill, Atherfield, Shanklin.
98. *Anomia radiata* Sow. in Fitton, G. T. 2d ser. vol. iv. pl. 14.
f. 5.
Loc. Atherfield, Sandgate.
- NOTE. Perhaps only a variety of the last species. Both are common, often adhering to *Gryphææ* and *Ammonites*.

(*To be continued*).

III. TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

I. *On the muddy deposits at the Mouths and Deltas of various rivers in Northern Europe, and the infusorial Animalcules found in those deposits.* By CHRISTIAN GOTTFRIED EHRENBURG.

[From the *Verhandl. der Königl. Preuss. Ak. der Wissenschaften zu Berlin*. 1843.]

THE Proceedings of the Royal Academy of Sciences at Berlin have, during the last two years, contained many interesting notices by M. Ehrenberg, on the extensive development of the skeletons of microscopic animalcules as a constituent part of the rocks of Central America and Western Asia. They are more or less abundant in all the limestones and cretaceous formations of these districts, as well as both in the Tripoli stones and blue marls of a more recent period, and in the oolitic limestones of an older age.

One of the most interesting results as regards geological investigations at which Professor Ehrenberg has arrived, is the circumstance of having discovered in the mud now deposited at the mouths of large rivers, forms of microscopic life and infusoria identical even in species with those found in the fossil state in the oolitic and cretaceous formations in every quarter of the globe.

Under these circumstances, we have thought it advisable to give a somewhat elaborate abstract of M. Ehrenberg's researches on this subject.

On the 10th July, 1843, M. Ehrenberg read before the Roy. Acad. of Sciences of Berlin a paper entitled "Observations on the perceptible Influence of Microscopic Marine Organisation on the Soil of the Bed of the Elbe above Hamburg."

The author in this paper states, that having already, in 1839, remarked the influence of microscopic organic life on the marsh lands of Cuxhaven, he continued his examination of the *humus* of the marshes; and amongst the numerous interesting results of these inquiries, none can be more important than those by which it appears that the microscopic animalcules of the Elbe, even at a considerable distance from its mouth, and as high up as Hamburg, cannot be distinguished from those inhabiting the ocean.

At the author's request, a friend at Glückstadt had sent him in the preceding year several specimens of earth and soil taken from the Elbe district, and at various depths and distances from the

river. Their examination produced the interesting and decided result, that the mud deposited by the Elbe, even at Glückstadt, (a distance of upwards of forty English miles distant from the mouth of the river,) is completely filled with the same microscopic marine animalcules, possessing siliceous or calcareous skeletons, which, according to a former report of the author, abound in the water at the mouth of the Elbe, near Cuxhaven, and many of which were figured in the Transactions of the Berlin Academy, in the year 1840. Thus these organic forms, which are better preserved at a depth of several feet than on the surface, existed in the arable land of the valley of the Elbe, which has been gradually accumulating during many thousands of years, and in this way is explained the origin of this soil in a more satisfactory manner than has hitherto been attempted.

It was a matter of great interest to M. Ehrenberg to ascertain how far up the Elbe this appearance of the direct influence of the sea on recent formations of land (already known to extend as far as Glückstadt,) could be traced. The author, therefore, procured several specimens of the mud of the river taken from three points near Hamburgh, and three-quarters of a league higher up the river.

The examination of the river deposits at Glückstadt and Hamburgh has proved the existence there of fifty-eight different species of microscopic marine animalcules, mostly obtained in a living state, and associated with many freshwater forms.

Of this number, twenty-three are entirely new, and chiefly of remarkable kinds, three of which seem to belong to new genera.

The fifty-eight species thus obtained, consist of thirty-four species of siliceous-shelled *Polygastrica*, twenty species of calcareous-shelled *Polythalamia*, and four species of siliceous vegetable remains, *Phytolitharia*.

Several of the forms collected near Glückstadt in the river mud still possessed their fresh ovaries, and must, therefore, have been taken alive. The specimens collected at Hamburgh were only the empty shells.

Both series of observations give a great preponderance of marine life over that of freshwater, and the species inhabiting the latter are not described in the memoir, as they present no new forms. The author gives the following as the results of his observations :—

1. The minute microscopic animals of the sea extend up the bed of the Elbe, (and this is probably the case, also, in all rivers directly connected with the ocean,) as far as the ebb and flood of the tide are perceptible.

2. The flood-tide in the upper districts of the river, even where the salt taste is no longer perceptible, as above Hamburgh, does not consist merely of an accumulation of the river waters occasioned by checking its outflow, but is now proved to be due to the direct introduction of the sea water, probably under the river water, and extending, very distinctly, as far as eighty English miles above the mouth of the river.

3. Since in the lower portion of the Elbe, the mud, consisting of a mass of clay and slime, which often interferes with the navi-

gation, only accumulates so far up as the flood tide is perceptible; but above this point, the bed of the river consists of pure siliceous and other sand, it is evident, that the cause of this singular phenomenon, which has hitherto not been sufficiently explained, is principally owing to *organic* conditions. It appears, in fact, that the mixture of river and sea water gradually kills vast multitudes of the minute organic bodies, and causes them to fall to the bottom, and form these accumulations.

4. The marsh land of the lower district of the Elbe, below Hamburg, and, probably, of all rivers flowing into the ocean, and considered as *humus*, does not merely or even chiefly consist of matter brought down by the stream from distant regions; and still less is it a local production of the minute animalcules existing in river water, but it is to a very considerable extent derived from organic beings existing in the ocean.

5. If we deduct the admixture of fine sand as a matter of uncertain origin, we shall find, not only at Cuxhaven, near the mouth of the Elbe, but also at Glückstadt, that from one quarter to one-third of the mass of fresh mud is owing to the influence of marine animalcules, and that above Hamburg, as far as the flood tide extends, the proportion is about half as great; but it has been already shown, that what appears to be fine sand may also, in a great measure, be an altered state of organic siliceous shells.

The author has obtained similar results from the examination of the mud of the Jahde in East Friesland and other places; and in a subsequent communication read to the Berlin Academy on the 27th November, 1843, he communicated the result of his further inquiries on the same subject, in the lower districts of rivers, particularly the Elbe, the Jahde, the Ems and the Scheldt.

In pursuance of his former investigations, the author proceeded to Hamburg and Cuxhaven, for the purpose of personally ascertaining the limits and extent of these phenomena. The river bed of the Elbe at Magdeburg, both on the shore and islands, consists of mere siliceous sand. Mud deposits of very slight extent are first seen in the neighbourhood of Hamburg, where the river is divided by numerous islands into the Haasburg and Hamburg Elbe.

At Hamburg, the author satisfied himself that these masses, specimens of which supplied the groundwork of his former communications respecting marine organic life in the Elbe, formed the chief integral mass of the islands known by the names of Reiherstieg and Köhlbrand. The channel has a depth of 7—8 feet at the ebb, and rises at the flood 5—6 feet higher. The surface of the islands is, generally, on a level with high-water mark, but in many places it is about 5 feet higher. This gives a positive height of the accumulated mud in the neighbourhood of Hamburg, of 15 or 16 feet. The middle channel has a sandy bottom.

Microscopic investigations have repeatedly shown, that in the very smallest portions of this mud the siliceous skeletons of marine animalcules are found, and that independently of all traces of organisation, which may, and even must, have become obliterated

after death, a proportional mixture of organic and chiefly solid elements may be approximatively, if not quite accurately, ascertained. This mixture may be assumed as amounting to not less than $\frac{1}{20}$ th of the volume, so that in 20 cubic feet of matter from the Hamburg islands, there exists not less than 1 cubic foot of animalcules, chiefly of marine origin, and provided with siliceous skeletons.

Another remarkable fact has resulted from these inquiries; that whereas during the month of July only the dead empty shells were found near Hamburg, the more recent researches have produced many living marine animalcules, preserving their yellow-brown and green ovaries in the natural healthy form and colour. The author mentions *Coscinodiscus radiatus*, *Actinoptychus senarius*, and *Gallionella sulcata*, as amongst the existing species found at the Reiherstieg near Hamburg; but he states that he has never found their forms in fresh water, either in the Elbe or in the Saale, and of the two first genera, which contain upwards of twenty species, none have ever yet been found in fresh water.

M. Ehrenberg has ascertained by numerous inquiries, and from various experiments, that no trace of salt could be detected in the Elbe water, even at high tides, at Hamburg, although such is the case at Glückstadt. Consequently as, notwithstanding this perfect purity of the upper portion of the river water at Hamburg, there can be no doubt as to a considerable deposition, and even continued existence, of marine animalcules in this district, the author can only explain the phenomena by assuming, that at high tides the salt water not only drives back the fresh water, but that the brackish water from the mouth of the Elbe also forces itself up the stream with great power, in the manner of a wedge beneath the fresh water, only stopping there where the tide ceases to flow, probably near Zollenspieker or Lauenburg.

Below Hamburg, the influence of these minute animalcules increases, and it even appears that the alluvial soil owes its greatest fertility to their presence. The thickness of the bed in which they there occur seldom exceeds 5 or 6 feet, and in this there is much drift sand included; but it remains still uncertain whether this so-called drift sand may not itself sometimes be derived from the decay of siliceous-shelled animalcules and the siliceous portions of plants.

The examination of other specimens from the Scheldt, near Antwerp, proved that there also existed in that river a similar relation between the sea and river formations. There were here found nine species of siliceous-shelled *Polygastrica*, and two species of calcareous-shelled *Polythalamia*. With the exception of three species, two of which were new, all these forms had been already observed in the Elbe, near Cuxhaven, and afterwards near Glückstadt and Hamburg.

It also appears from the examination of numerous specimens from East Friesland, the districts of the Jahde and the Ems, and the neighbourhood of Nordeney and other points of the coast, that

the mud formation, deposited at the mouth of the Jahde, and the other localities, contains innumerable multitudes of the same calcareous and siliceous-shelled animalcules as those existing in the Elbe; and further, that the Ems as far as the strong flood tide rises (which, according to Dr. Pressel, extends to Halte and Weener), is like the Elbe, extremely rich in calcareous and siliceous-shelled microscopic marine animalcules, and that the rich slimy deposit is only observed so far as the flood tide rises.

The author found in the mud taken out of the Ems, three-quarters of a league below Weener, and about forty miles from the North Sea, thirty-seven species of siliceous-shelled *Polygastrica*, and nineteen species of calcareous-shelled *Polythalamia*, most of which are the same as those found in the Elbe. The list, however, contains nine new species of *Polygastrica*, and eight of *Polythalamia*. One of the *Polygastrica* constitutes, indeed, a new genus, and is particularly interesting as illustrating the nature of fragments found in the chalk marl of Ægina, and described in a former paper. In the mud of the Dollart from the harbour of Emden, most of these forms also occurred together with *Miliola ovum* and *Rotalia egena*.

In the pure sea mud from Nordeney, the above described species of the Elbe, the Scheldt, and the Ems were most abundant, and were associated with a few peculiar and partly new forms. On the whole, there were twenty-eight species of *Polygastrica*, and nine of *Polythalamia*. Almost the same species occur again in the mud of the Jahde, near Hocksiel in Jeverland.

All these mud deposits are quite superficial, and form the upper bed of the bottom of the sea, and, like drift sand, sometimes form islands above the action of the tides. The observations which have been made to a greater depth had, however, produced very interesting results, similar to those which have been already obtained near Glückstadt.

In Jeverland, at a depth varying from 15 to 29 feet under layers of earth called *Watt-sand* and *Klei* (wet or quick sand, and clay), there is often found a black elastic bed 1 or 2 feet thick, known by the name of *Darg*. Piles driven 28 or 29 feet deep into the sand are checked on this elastic layer, but on breaking through it, are easily driven 12 or 18 feet deeper, without further check. This formation, according to Herr von Thünen, occurs in almost all the marsh lands between Jutland and Friesland, as well as in the English marshes far outside the present dikes, and a more accurate knowledge of this substance is greatly wanted, and is necessary for the proper understanding of the earliest formation of these marshes. The author had, in former years, observed a similar condition in the Baltic, near Wismar, where on the island Lang-Ort, near Pöhl, a turf-like submarine substance in cakes of the size of a hand, is broken off and thrown on the north shore of the island, and is easily recognised as a half-dried mass, containing numerous microscopic marine animalcules.

The *Darg* of East Friesland, taken from a depth of 15 feet, ex-

hibits, when examined by the microscope, many vegetable remains, chiefly *Fuci* and *Zostera*, and with them are found twenty species of *Polygastrica* and one of *Polythalamia*, forming principal constituent parts. This Darg is, therefore, decidedly a marine, and not a freshwater formation, and contains the same forms of animal life as those which now inhabit the North Sea.

Moreover, M. v. Thünen has found at a depth of 4 and 8 feet in Jeverland, along the borders of an old island, a blue sand of great fertility, which is collected and mixed with the arable soil. The examination of this sand has proved that it also contains microscopic organised beings, with calcareous and siliceous shells in great abundance, and of the same genera and species which have been above described.* Thus it is no freshwater formation, but a decided product of the sea.

The author has also had an opportunity of examining specimens from the Holstein marshes, chiefly from Brunsbüttel on the Elbe, and partly from Wöhrden, near the Eyder. At the latter spot, the marsh soil 3 feet below the surface contains twenty-seven species of siliceous-shelled *Polygastrica*, six species of siliceous vegetable fragments (*Phytolitharia*), and one species of *Polythalamia*, all of which, with two exceptions, *Actinocyclus sol* and *Surirella linea*, are identical with species now living in the North Sea at the mouth of the Elbe, near Cuxhaven, and most of which extend as far as Antwerp.

The author has lately found many of the above-mentioned North Sea forms in the mud of the sea, and of the rivers near Liverpool and Dublin, and many of them are also found in the Mediterranean, where, however, the forms are, in general, very distinct.

In conclusion, the author feels bound to remark that many of the very numerous forms which are found so extensively distributed along the coasts, and in the arable and marsh soils on the shores of the North Sea as well as in the bottom of the North Sea itself, are entirely wanting in the Baltic and along its coasts. Thus the *Tripodisci*, the *Tetrapodisci*, the *Nonionina germanica*, *Auliscus* and *Cerataulus*, together with *Zygoceros* and *Geoponus stella borealis*, have not been found any where in the Baltic, nor in any deposit along its flat shores, although most careful inquiries were made throughout the whole basin of the Baltic, in Mecklenburg, Pomerania, East Prussia, Finland, Sweden and Denmark.

The author believes that, if these observations should, when further carried out, prove any local distinction of forms, in consequence of the greater extent to which most of the other species can be traced, it will also appear less probable that the basin of the Baltic Sea could ever have been in more direct communication with the North Sea than it is at present; and, likewise, that the extensive beds of Infusoria at Kliecken, near Dessau, and at Oberohe in Luneburg, which overlie the brown coal sand, cannot by any possibility belong to the marine formations of the North Sea, and that the greater deposits of the Spree and the Havel at Berlin and Spandau, and on the banks of the Oder, near Freien-

walde, are equally unconnected therewith, the latter only bearing comparison with the forms of the Baltic.

The marshy grounds and extensive cultivated lands at river mouths near the ocean are therefore not entirely, and perhaps not even principally, δῶρον τοῦ ποταμοῦ (a river gift).

W. J. H.

II. *Account of various portions of the GLYPTODON, an extinct Quadruped, allied to the Armadillo, and recently obtained from the tertiary deposits in the neighbourhood of BUENOS AYRES.*

[Extracted by permission from the last volume of the Descriptive Catalogue of the Museum of the Royal College of Surgeons in London.]

SEVERAL portions, including the nearly entire skeleton of the hind foot of a singular edentate animal, were described by Professor Owen in a paper printed in the sixth volume of the "Transactions of the Geological Society" (p. 88. *et seq.*), and were referred by him to a new genus, called *Glyptodon*. Since the publication of this memoir the complete carapace of the animal has been obtained, and more lately a number of other remains, referred to three other species of the same genus from which the whole anatomy of this animal has been determined. The account given in the present article is taken, with scarcely any alteration, from a detailed description of such specimens of the *Glyptodon* as are now in the possession of the Royal College of Surgeons, recently published in the descriptive catalogue of the Museum of that institution by Professor Owen.

The specimens in the Museum of the College consist of the cranium, the carapace, the tail, and the bones of the hind leg and foot of the *Glyptodon clavipes*, and of some fragments of the carapace of three other species.

At least three species are also known by specimens now in the British Museum, one or two of which are identical with the species here described. The species described by Professor Owen are named respectively, *Glyptodon clavipes*, *G. tuberculatus*, *G. ornatus*, and *G. reticulatus*.

ED.

1. *Glyptodon clavipes*.

1. *The cranium*. The occipital condyle presents a convexity in the vertical direction, which describes more than a semicircle, and is slightly convex transversely, but is narrower in that direction than it is in the *Myiodon*: it is directed in the *Glyptodon* backwards and obliquely outwards. The occipital foramen is very large and transversely elliptical; its plane is inclined from below

upwards and backwards 20° beyond the vertical line. The anterior condyloid foramen, though large, is relatively smaller than in the *Myiodon*, and is situated close to the anterior border of the condyle. The depression for the digastric muscle is perforated and separated from the condyle by a wider tract of the par-occipital than in the *Myiodon*, and the petro-mastoid below the digastric depression presents a rough convexity, bounded posteriorly by a transverse ridge of the par-occipital, instead of the hemispherical depression for the articulation of the stylo-hyoid bone, which characterises the skull of the *Myiodon*. The basi-occipital presents a median smooth concavity and two lateral rough depressions which are continued on to the basi-sphenoid, and indicate the insertions of very powerful "recti capitis antici majores:" the obliterated suture between the basi-occipital and basi-sphenoid forms a rough transverse ridge: the inequalities of this part of the basal region of the skull present a striking contrast to the broad, smooth, and even tract which the same part forms in the *Myiodon*.* The sides of the concave under surface of the basi-sphenoid are bounded by longitudinal ridges, which have been broken off in the specimen. The petrous bone terminates by a prismatic pointed process in the foramen lacerum, which here gives passage both to the jugular vein and internal carotid. The foramen ovale is circular, and of the same size as the anterior condyloid foramen. The foramen rotundum is one inch and a half in advance of the foramen ovale, and opens into the commencement of a deep and long groove which traverses the base of the pterygoid processes in the direction towards the ant-orbital foramen. The base of the zygomatic process supporting the articulation of the lower jaw is brought much nearer the occiput than in the *Myiodon*, and is separated from the petro-mastoid by a deep excavation perforated by wide apertures that seem to communicate with the tympanic cavity. The articular surface for the lower jaw is well-defined, narrow in the axis of the skull, much extended transversely, gently convex in both directions. In the skull of a recent Armadillo (*Dasypus octocinctus*), the articulation for the lower jaw is almost flat and on a level with the roof of the posterior perforated cavity: in the *Prionodon* (*Dasypus gigas* Cuv.), the articular surface is slightly concave and extends longitudinally forwards from the posterior cavity: the zygomatic process of the malar bone bounds the outer and fore part of the surface, and extends forwards in the form of a laterally compressed plate of bone, and in the *Das. sexcinctus* forms a slight angular projection below the ant-orbital perforation. In the *Glyptodon* the articulation for the lower jaw more resembles that in the ordinary Pachyderms, and is thus conformable with the deviation from the Edentate structure manifested by the bones of the foot. But the most remarkable characteristic of the skull of the *Glyptodon*, by which it differs from the existing Armadillos and approaches the Megatherioids, is the long and strong process

* See Memoir on the *Myiodon*, 4to, pl. iv.

which descends from the base or origin of the zygomatic process of the maxillary bone. This process is compressed, but in the opposite direction to that in the *Myiodon*, viz. from before backwards, instead of from side to side: it measures five inches in length from the ant-orbital perforation; one inch and three-fourths in breadth across the middle: the outer margin is entire, and as if folded back; the lower half of the inner margin is slightly notched, the extremity of the process curves backwards. Both anterior and posterior surfaces bear strong marks of the attachment of muscular fibres. The small remaining portion of the maxillary bone on the inner side of this process shows portions of three deep sockets of the same diameter throughout, indicating the implantation of molar teeth by a single excavated base; and showing two longitudinal ridges on both the outer and the inner side, which proves the teeth to have had the same fluted exterior which they present in the lower jaw, and of which the generic name of *Glyptodon* is expressive. The fractured anterior part of the "basis cranii" shows the large cavities for the olfactory bulbs and the remains of a very extensive cribriform plate, the organ of smell being very largely developed.

The posterior or occipital surface of the skull slopes forward from the plane of the occipital foramen at an angle of 45° : in the small existing *Armadillos* it is vertical: in the *Glyptodon* it is divided by a strong median vertical ridge, and separated by a sinuous, thicker, transverse ridge from the upper surface of the skull. The posterior half of this region of the cranium is marked by the ridges bounding the origins of the temporal muscles, which almost meet along the middle or sagittal line. Part of the lambdoidal suture is seen; the other cranial sutures are obliterated. The temporal fossæ are pierced by numerous large vascular foramina. The anterior parts of the temporal ridges diverge to the posterior angles of the supra-orbital ridges. The frontal or inter-orbital part of the upper surface of the cranium is broad, and nearly flat, smooth and slightly concave at its posterior half, slightly convex, rough and perforated by vascular foramina at its anterior half. The most prominent parts, above the orbits, are most rugose and indicate a more intimate adhesion to the super-incumbent osseous dermal helmet. The lacrymal foramen is pierced immediately in front of the anterior border of the orbit.

The difference in the development of the temporal muscles manifested by the *Glyptodon* and *Myiodon*, in the position of the ridges on the fossil cranium, indicates a corresponding difference in the power of mastication and in the density of the alimentary substances habitually selected by each species: the greater proportion of hard dentine in the teeth of the *Glyptodon*, and the greater number of the teeth, which appears to have been thirty-two, eight on each side of both jaws, coincide with the characters of the cranium and support the inferences thence deducible.

2. *The Carapace.* It is composed of thick, pentagonal ossicles

united together at their margins by sutures: smooth on the inner surface where the sutures are most conspicuous, rough and sculptured on the external surface according to a definite pattern characteristic of the species, the whole forming a symmetrical, oval, convex, bony case or shell which covered and defended the upper and lateral parts of the entire trunk of the animal.

The following are the dimensions of this carapace:—

	feet.	inches.
Length, following the curve of the back - - -	5	7
Ditto in a straight line, or the chord of the arc - -	4	8
Breadth, following the curve of the middle of the back -	7	4
Ditto in a straight line, or the chord of the arc -	3	2 $\frac{1}{4}$
Ditto of the anterior outlet or arched margin at the base of the arch - - - - -	1	5
Ditto of the posterior outlet, at do. - - - - -	1	8

The component ossicles support on their outer surface a central, large, subpentagonal or subcircular flattened eminence, surrounded generally by five or six smaller discs; both being rough, but especially the peripheral ones. In the ossicles near the margins of the carapace the middle eminence increases, whilst the peripheral tubercles diminish or disappear. At the anterior margin the middle eminence extends outwards and forwards as a transversely oblong obtuse projection; at the lower margins near the posterior part of the carapace it extends outwards in the form of an angular process: the ossicles at the posterior margin are the largest, and have a pentagonal shield-shaped figure; the two smaller sides being wedged into the interspace of the two ossicles of the penultimate row.

None of the ossicles are modified, as in the smaller *Armadillos*, to form transverse bands connected together by moveable joints, and allowing the carapace to be closed over the retracted head and legs: such a defensive modification of the bony armour was not required for the gigantic *Glyptodon*.

There are forty-four transverse series of ossicles in the present carapace which extend from above, downwards and obliquely backwards: the longest series at the middle and broadest part of the carapace contain each seventy ossicles; the number gradually decreasing, as the carapace contracts in width towards the two extremities, the anterior margin being composed of sixteen ossicles, the posterior one of twenty-five ossicles: the total number of these dermal bones may be estimated at above two thousand in the carapace of the trunk of the *Glyptodon clavipes*. To these, in the consideration of the dermo-skeleton of the extinct species, must be added the casque defending the head and the verticillate armour of the short and thick tail.

3. *The tail.* The fossil tail of this animal measures one foot six inches in length, is almost circular at its base, and becomes slightly depressed towards its apex; it is gently curved with the concavity upwards through its whole extent, and consists of a

series of caudal vertebræ inclosed in an inflexible sheath composed of closely united dermal ossicles of various forms and sizes, but disposed in a regular and beautiful pattern. The osseous substance of the sheath increases in thickness from half an inch near its base to one inch and three quarters near its obtuse apex. The dermal ossicles are united to the internal skeleton of the tail, and defended from outward pressure by processes which radiate from the bodies of the caudal vertebræ. The dermal armour consists of central, large, or principal ossicles, and peripheral, small, or accessory pieces, the latter occupying the interspaces of most of the larger ossicles in a single series. The larger ossicles differ in size, increasing as they approach the end of the tail, and with great regularity, where they form the two lateral series, which terminate by a pair of large, sub-elliptic, thick, hollow ossicles, which inclose the end of the tail like a bivalve shell, defending this part when dragged along the earth and even enabling it to pierce the soil like an implement sheathed with iron. The number of the lateral plates on each side of the considerable portion of the tail preserved is nine; from the first of these to the fourth the number of intermediate principal ossicles below each pair of lateral plates is six of nearly equal size; beyond this they decrease to four and three in number. At the superior interspace of the two lateral series there are six sub-equal principal ossicles between each pair of lateral plates as far as the fourth; they then decrease to five and four in number, those at the centre being of smallest size.

The circumference of the base of the tail is fourteen inches, that of the apex at the interspace of the penultimate and last lateral plates ten inches. The length of the last lateral plate is three inches and a half, its breadth is three inches.

An anterior caudal vertebra is another interesting fossil with reference to this part. The specimen exhibits part of the anterior border of the verticillate bony dermal covering or sheath of the tail. This covering was attached to the vertebra by a close syndesmosis connecting the extremities of the processes which radiated, like the spokes of a wheel, from the centrum or body; the muscular and ligamentous tissues, which occupied the interspaces now filled by the matrix or soil formation in which the fossil was imbedded, would also form a medium of attachment between the endo- and exo-skeletons of the tail. The length of the body of this vertebra is two inches and a half: the diameter of the articular surface of the body is one inch and a half.

2. *Glyptodon ornatus*, Owen. .

This species is indicated by a portion of a carapace, including four or five dermal ossicles of a smaller species of *Glyptodon* than the one already described. The outer surface of the ossicles is relatively smoother, and the central disc smaller as compared with

the peripheral discs, which are seven in number in each ossicle, and give its exterior surface the figure of a rosette.

This specimen was obtained from the tertiary deposits near the Rio Matanza, about twenty miles to the south of the city of Buenos Ayres.

3. *Glyptodon reticulatus*, Owen.

This animal must have been a gigantic Armadillo, as large as the *G. clavipes*, but differing in the sculpturing of the external surface of the component ossicles, in which the peripheral raised portions are of equal size with the central one, making the whole exterior appear to be impressed by channels in the form of a network. Hence the name by which the species is indicated.

4. *Glyptodon tuberculatus*, Owen.

This species is determined from a fragment of the carapace of a gigantic extinct Armadillo, nearly equalling in thickness the preceding specimen, but having the outer surface of the ossicles divided into much more numerous elevations, separated by narrower channels which unite to form a closer net-work: each eminence or tubercle, of which there are between forty and fifty on each ossicle, has a punctate surface.

There is also a fragment of the carapace of the *Glyptodon tuberculatus*, in which the component ossicles are square-shaped, and, although the sutures are close on the smooth internal surface, yet the tuberculated external surfaces of the ossicles are divided by deep channels. The size and shape of the tubercles are so similar to those in the foregoing specimen as to lead to the suspicion that the different form of the ossicles may have depended on a modification of a particular part of the carapace. The analogy, however, of the *Glyptodon clavipes*, in which species the specimen in the Museum of the College affords the opportunity of studying the extent of modification to which the constituent ossicles are subject in the entire carapace, militates strongly against the supposition that the various sculpturing exhibited in this and the other specimens above described could have characterised particular parts of the carapace of the same species.

This specimen was obtained from the tertiary deposits in the Pampas of Buenos Ayres.

III. On the BOULDER FORMATION and on DILUVIAL SCRATCHES IN DENMARK and part of SWEDEN. BY G. FORCHHAMMER.

[From *Poggendorf's Annalen*, bd. 58. s. 609.]

THE several formations of clay, sand, and boulders, all comprehended under the general term "Boulder formation," have lately occupied the attention of geologists. For the study of the Scandi-

navian boulders, it would be difficult to find a country which affords so much assistance in solving the most difficult problems on the subject as Denmark, where an extensive line of coast offers numerous opportunities of obtaining an insight into all the circumstances relating to the rocks of that country. I have occupied myself for many years in endeavouring to make out the geological relations of Denmark with regard to this matter, and I may be allowed to state at the outset, that the notion of this boulder formation being a mere surface phenomenon is quite incorrect, since it has reference to the whole tertiary period, even reaching so far back as the time of the deposit of the newer cretaceous beds. It will be necessary therefore to recapitulate briefly the relations of the cretaceous rocks in Scandinavia.

The carbonaceous deposits of Schonen and Bornholm, which contain a great number of iron-stone bands, and which from their fossils might be referred either to the Lias or the Jurassic period, are succeeded at Bornholm by another carbonaceous deposit without iron-stone, and containing no other fossil than *Fucus intricatus*. This newer deposit seems identical with the Carpathian sandstone and other fucoid sandstones of the Alpine chain, and does not belong to the lower part of the cretaceous series; but upon this bed, which has not yet been found in Schonen or in Denmark proper, the upper greensand is superimposed unconformably, the lower series being frequently inclined at high angles (50° or 70°) towards the old rocks in the vicinity, while the overlying rocks dip only at an angle of about 10° , and that in the opposite direction.

The upper greensand appears on the south-west coast of Bornholm and in Schonen, where it has been described by Nilson. It consists partly of sandy and partly of marly beds, whose fossils are the same in both of these districts. The greensand is succeeded at Bornholm in regular development and conformable stratification by the marly limestone of Arnager, resembling very closely the Saxon *Pläner*. In Schonen there only appear in detached portions masses of limestone consisting of fragments of shells and corals, and these are probably referable to the upper greensand.

During the past winter I have been so fortunate as to discover in the neighbourhood of Kjöge in Seeland a greensand, which most probably belongs to this part of the cretaceous period. The presence of the easily worn schists of this formation explains the deep intersection of the Kjöger Bay, between the hard Saltholm limestone of Amack and the fire-stone bands of Stevens Klint. The abundant springs of Bröndkilde, Rothschild, &c., belong to the same formation, and all of them strike S.E. and N.W.

In the south-western part of Schonen, on the island of Saltholm, in Sunde, below Copenhagen, and in Jutland, in the neighbourhood of Greenaae, a band of limestone appears which may be traced by detached fragments and reefs in the Cattegat, between the points before mentioned. This limestone, which is hard and compact, seems, according to its geographical position, to underlie

the white chalk, but it has not yet been found in direct association with any member of the cretaceous group, although its fossils show it to belong to that period.

The white chalk forms a considerable part of the south of Seeland and of Möen, the chalk of Stevens Klint dipping away in those localities at a very small angle to the south-west, while the chalk of Möen is considerably upheaved. The second principal part of the white chalk may be traced from Mariagerfjord, across the Liimfjord to the western sea. The south-eastern part of this portion of the chalk at Mariagerfjord and eastern Liimfjord is regularly interstratified with horizontal layers of fire-stone, whilst the north-western part at the western Liimfjord, and at the North Sea, are very irregularly elevated, and, as at Möen, the boulder formation is made up of its fragments. In this most northerly part of the chalk formation numerous landslips occur, and some years ago the Norr-See in this neighbourhood was completely emptied by one of these slips occurring in its bed without any apparent outlet being discovered for the swallowed up waters. The whole district must be completely undermined with subterraneous canals, and the inhabitants conduct the drainage of their fields into the funnel-shaped hollows of the landslips, where the torrents poured down during the most tremendous storms, and the sudden melting of the snows in spring, all instantly disappear. Besides these principal portions, the chalk is also seen in detached points near Steenløse in north Seeland and near Itzehoe in Holstein; and these facts considered in connection with its re-appearance at Heligoland and Lüneburg, prove that the whole country rests upon a cretaceous basis, although it is only brought to the surface by local disturbances.

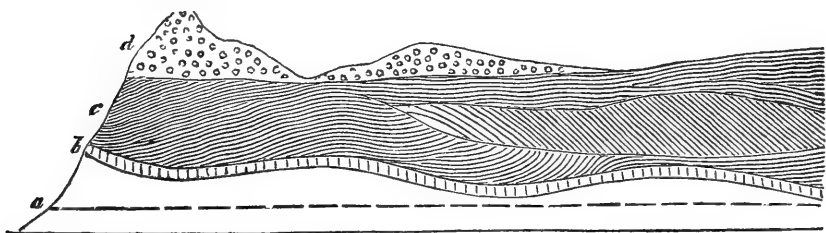
In the cliff of Stevens Klint, the sequence of the newer rocks of the cretaceous formations is very clearly seen. It is as follows:— On the white chalk there reposes a formation of slaty clay, only a few inches thick, but extending over the whole country so far as can be judged by considering the places at which these newer cretaceous rocks are exposed. It is characterised by a vast multitude of the fragments of fishes, which, however, are too imperfect to allow of their being very distinctly made out. Next follows a limestone which is from 1 to 2 feet thick only in this spot (Stevens Klint), but at least 40 feet thick in the hill of Faxoe, a few miles distant, where it is exhibited as a perfect coral reef. In the north-west of Jutland, this bed re-appears in the form of a thin stratum.

Another limestone succeeds this at Stevens Klint, which is made up of calcareous sand, almost exclusively composed of fragments of corals together with fragments and well-preserved individuals of other fossils of the chalk. This, which is called in Jutland *Limsteen*, and which I propose to call “coralline chalk,” is quite different from the underlying strata of the cretaceous group; and the separate strata may be traced in undulating beds through the whole thickness of the formation in such a way that the same unfractured

stratum, which in one place is the uppermost, in another, at no great distance, is the lowermost.

This kind of false stratification is seen in recent accumulations on our own coast, under certain circumstances.

VIEW OF THE CLIFF AT STEVENS KLINT.



The annexed diagram represents a portion of the cliff of Stevens Klint. Here (*a*) represents the white chalk, with nearly horizontal thick layers of firestone ; (*b*) is the slaty clay and Faxoe limestone ; (*c*) the coralline chalk with its curious contortions of strata ; and (*d*) a conglomerate made up of great angular lumps of the coralline chalk and firestone, cemented by a calcareous paste.

As there is no mark of disturbance of the subjacent rocks in that cliff, I suppose that the undulating stratification arises from the material having been deposited in a very much agitated sea, in the condition of pounded fragments, derived from the degradation of rows of coral reef parallel to the direction of the mountain chain, or rather of its axis of old rocks. This view is rendered more probable by examining a formation of the same age as the coralline chalk, which forms a zone parallel to it to the south-west of the chain. This bed is a limestone resembling chalk in colour, but which cannot be used to write with ; it seldom contains fossils ; and though not horizontal, is by no means so strongly undulating as the coralline chalk, and is often intermediate in position between this latter rock and the white chalk.

I look upon it as formed out of the finer particles of the pounded reef, and deposited at a greater distance than the coralline chalk from the spot where the degradation of the coral reef was going on. It has the same relation to the coralline chalk as the marshes on our western coast have to the sandy sea-shore ; and it seems clear that the disturbing force proceeding from the Scandinavian mountains in one place aid in the formation of the coral reefs, but tend also in another quarter to destroy these solid masses of rock.*

* M. Forchhammer considers that the dependence of the existence of coral reefs on volcanic operations going on beneath the sea is an established fact, and that the coral polyps could only obtain the necessary supply of carbonate of lime to continue their operations by means of a considerable evolution of carbonic acid. He also thinks that the forces which elevated Scandinavia first exhi-

The formation resting immediately on the cretaceous beds is one which covers by far the greater part of Denmark. It is the important *Brown coal series*, of which there are three great deposits. The one of these farthest from the mountains, and that which is the most regularly stratified, extends from Nissumfjord to the south of Liimfjord, on the ridge of the land, and on the west coast as far as the Elbe; it re-appears through the gypsum upheaved near Lüneburg, and unquestionably forms a large part of the Lüneburg common. The uppermost bed consists of ferruginous sand and a loose sandstone; and below this are thick beds of clay and marl, occasionally including unusually hard marly limestone.

Alum earth is also very common, and in detached spots there is found a snow-white sand with mingled white clay, abounding with glimmering particles; while in the middle of Jutland by Them, beds of brown coal appear in sand. The great abundance of brown coal in this formation is best shown, however, by the fact that the Western Sea throws up this substance along the whole line of coast from Liimfjord as far as the Elbe. There can be no doubt also, that the amber belongs to this formation, since the amber is thrown up in the same places in which the brown coal appears, and to such an extent, that about 3000 pounds weight are annually procured. The clay and limestone of this formation, and sometimes also the sandstone, contain fossils which mark the age of the deposits to be identical with that of the sub-Apennine group. Among the most important of these are, —

Cassis testa,
Cassidaria echinophora,
Nucula comta,
———— glaberrima,
Fusus corneus,

Pleurotoma cataphracta,
Dentalium striatum,
Trochus agglutinans,
Triton anus,
Isocardia cor,

together with another *Isocardia* somewhat different, and a *Rostellaria* very much resembling *R. pes pelicani*. There are also found crabs overgrown with species of *Balanus*, and the bones and vertebra of Cetaceans. The fossils are, however, on the whole not very common, and chiefly appear heaped together on the south-eastern side of the island of Sylt. On this island the members of the formation before described are seen upheaved by an elevation corresponding to that of the island of Heligoland, and striking N. N.W. and S. S. E., the beds dipping towards the E. at angles varying from

bited themselves by a liberation of carbonic acid providing material for the coral reefs. Afterwards, however, the forces increased and elevated the mountain chain, the powerful waves thus produced destroying the coral reefs and depositing the coarser fragments, as coralline chalk and the finer mud, at a greater distance from the centre of disturbance as newer chalk.

This he supposes to be the first result produced by the elevation of the Scandinavian mountains in the way of filling up the bed of the sea from the subsequent elevation of which Denmark was formed. Rolled Scandinavian rocks are not found in the coralline chalk, where we rarely find any thing larger than grains of sand and very small stones. (p. 614.)

15° to 80° This whole western part contains only small boulders, and consists almost entirely of fine-grained sandstone, made up of the quartz rock which so greatly abounds in the transition rocks. Firestone also occurs.

The case is quite different on the coast of the Cattegat. On the island of Seeland the Brown coal formation appears in the north-west at Cape Refsnaes, and on the north-western side of the island of Fühnen, on the north-eastern side of the duchy of Schleswig, and on the eastern side of Jutland in the island of Samsøe, and again on the south-western shore of the Cattegat. The arenaceous members of the formation are here entirely absent, and the rock consists of clay, which is sometimes of fine laminated texture, and of variegated colours (blue, green, and red), and sometimes of a black and brown colour, and glimmery appearance, forming an excellent alum shale, and containing imbedded pyrites. Below this are limestones, and here and there kidney-shaped masses of radiating heavy spar, very much like Bologna spar, and not seldom including masses of corals. Carbonate of iron and thick brown spar likewise appear, and many crystals of aragonite are distributed through the hard strata. The beds of this series are variously elevated, but always by local elevations, so that no general law of the disturbances can be discovered.

I now proceed to give an example of the different contents of the strata of this interesting group, as they appear in the neighbourhood of Fredericia.

The finely laminated clay is here curved and bent in the way which one sometimes observes in gneiss. A little hill, near the town, is capped by a bed of newer date (the boulder clay), which appears to have suffered no change, and it is clear that the principal disturbance must have occurred between the deposit of the Brown coal and that of the boulder sand. It is worthy of remark that the relative proportion of fragments of the cretaceous rocks is always very small, varying from eighteen per cent. in northern Fühnen to twenty-five per cent. in other places; the rest is made up of about fifty per cent. of the old rocks (*Urgebirge*), and thirty per cent. of transition rocks (*Uebergangsgebirge*). This is singular, since the Brown coal formation rests immediately upon the rocks of the cretaceous group, and one might therefore have expected that many fragments of the latter would be included, but such is not the case; and the newer deposit of the boulder clay is much richer in this respect, containing fifty per cent. of cretaceous rocks. It is also worthy of notice that only that part of the Brown coal formation, which flanks the western edge of the Scandinavian mountains, contains these boulders, and also that while not one single specimen of *Pecten* is found in the whole of the western Brown coal system of Jutland, fossils of this genus are very common in the Cattegat system, other species of shells however (e. g. *Nucula lævigata*, *N. comta*, and *Pleurotoma oblonga*) belonging to both, and apparently proving the contemporaneity of the two deposits. The cause of this peculiarity, viz. the absence of the

Pectens, may have some connection with the abundance of amber and brown coal in these localities, the cause being that the western part of the formation was deposited on the nearly level shores of a sandy country, while the brown coal of the Cattegat was derived from a district occupied by the old rocks, which formed the immediate shores of a deep sea.

The third system of the Brown coal formation is exhibited on the islands of Mors and Fuur, in Liimfjord, and at several places on the western shores of the fjord. The deposits of this part consist of black clay and black unconsolidated sandstone, resting on black limestone, these beds being overlaid by a very thick bed of white infusorial siliceous earth, with subordinate layers of ferruginous limestone, the whole being finally covered up by a yellow sandstone and conglomerate. The stratification of the whole is greatly disturbed.

This formation is of freshwater origin, and contains insects, fragments of freshwater fishes, and an immense multitude of a small species of *Spirorbis*; but its relation to the marine beds of western Jutland is evident in several places, strata of brown coal, containing *Cassidaria echinophora*, appearing in the island of Mors, and a black limestone, with *Nucula glaberrima*, in Thyé. Boulders are only found in the uppermost or sandy member of this series, and are there very rare.

The next great division of the boulder formation of Denmark I have called "Boulder clay." It includes clays of yellow and blue colour, and marls and sand, and throughout the whole, boulders are distributed whose dimensions vary from the size of several hundred cubic feet to that of a grain of sand. This formation has been traced to the depth of several hundred feet, and the boulders are distributed throughout the entire mass, their occurrence being unquestionably not merely a surface phenomenon, but extending to the deepest part of the series; and the more common appearance of the boulders at the surface is owing to the fact that the finer portions have been washed away by a more recent denudation, which however was not sufficiently powerful to remove the larger blocks.*

Of the series now under consideration, the yellow and blue clay with boulders is very rarely stratified, but here and there a slaty clay appears without boulders, and the sandy portions generally, although by no means always, exhibit stratification.

The irregularity of the interior of this deposit shows itself in the external surface,—the whole forming a much intersected, hilly district, without any regular chain being traceable, and the fertile soil of the trough-like valleys is thickly covered with beech trees, or the land is turned into corn-fields or used for pasture. This formation is distributed here and there over most parts of Denmark, but covers entirely the southern part of the island of Seeland,

* On the cliffs of Visborg in the island of Samsøe this alternation of finer with coarser boulders is clearly seen repeated as many as four times.

almost the whole of Fühnen, most of the Danish islands of the Eastern Sea, except Bornholm and the east coast of the peninsula of Randers as far as Lubeck. In the duchy of Schleswig, the beds of it so alternate with those of the Brown coal formation, that no distinct limit can be traced, and I should thence conclude that its oldest part is of the sub-Apennine date; although, on the other hand, a blue clay, sometimes with and sometimes without boulders, is found also in the duchy of Schleswig and in other places, which contains, in great abundance, fossils of a much newer period; among which are *Cyprina islandica*, *Corbula nucleus*, and the vertebræ of fishes. This blue clay is much used for brick-making, and, in some of the pits in which it is dug for this purpose, it is found to alternate with a boulder clay, the beds being inclined at a high angle, but dipping in various directions and at various degrees of inclination. Deep wells sunk in some of these pits near Apenrade, in the duchy of Schleswig, have sometimes given off suddenly large quantities of carbonic acid gas; and, on one occasion, in 1841, three men lost their lives from this cause in a well they were digging, and which they had left the night before free from gas. The gas remained from April to August in this well, and rose and fell according to the state of the barometer, rising as the mercury in the barometer sank.

The distribution of the boulders in the boulder clay formation is very important. Blocks, several cubic feet in content, abound throughout: but none are so large as the remarkable boulder on the east coast of Fühnen which, in 1840, was standing 11 feet above the ground, and measured 105 feet in circumference, but which has since been shown to be embedded in the earth to a considerable depth, 10 feet more having been now exposed, and the circumference continuing to increase.

All the larger blocks are of granite, granitic gneiss, porphyry, syenite, greenstone, and quartz rock. Among the boulders of smaller size firestone and fragments of the chalk formation begin to appear and constantly form a larger proportion of the whole as the size of the boulders diminishes. In order to compare the contents of the boulders of different formations at different places, I assumed, as mean sizes, those between the dimensions of the closed single hand and the two hands together; and I have now made calculations with regard to several hundred from different parts of the country which have conducted me to unexpected results.

In the line of junction between the limestone of Saltholm and that very similar limestone which appears in the neighbourhood of Greenaae in Jutland the boulders of the Saltholm limestone are so common that upwards of 20,000 tons of them are annually burnt for lime. The moment, however, that the line of junction is passed, the boulders of this rock become rare, and soon disappear; so that since we cannot but assume that this bed continues in the same direction beneath the other, it results that these boulders have been very little removed from their parent rock. On

the island of Langeland, especially on its southern part, fragments of the transition rocks average 35 to 40 per cent., taking those which have the dimensions before alluded to, and this proportion continues as far as South-eastern Holstein, but towards the north it diminishes rapidly, and in South Fühnen it is hardly 20 per cent., while still farther to the north it is yet smaller.

In middle and northern Seeland, in part of Fühnen, and the northern part of Jutland, the rocks of the chalk formation form about one half of the whole number, and in some places increase to 70 per cent.; while in two spots, in looking for these boulders, I have found the cretaceous rocks *in situ* where their presence had not before been suspected. On the western banks of the Liimfjord the transition rocks again appear, and reach to a proportion of 40 per cent. or more; but there are here porphyry, syenite, and transition sandstone evidently belonging to the northern Christiania series.

Advancing southwards from the Liimfjord towards the Brown coal formation, the porphyry is seen to disappear gradually, while the transition sandstone increases so much that 76 per cent. of the whole number of boulders are of this material, and the rocks of the cretaceous series are either totally absent or are reduced to a very small proportion. In the western part of Schleswig the former (the sandstone) diminish rapidly, while the latter (the cretaceous boulders) increase, and in the middle of Holstein, near Itzehoe, the chalk comes out to the day.

If we consider these relations more closely we shall find that the cretaceous rocks and limestone of this series cannot have been transported from the Scandinavian peninsula, but are derived from the actual rocks of the country; and that they cannot have been drifted from any great distance is proved by the enormous increase in the proportion of cretaceous boulders near the outcrop of the chalk. Of the innumerable local disturbances which have thus broken into fragments the various fundamental rocks of the country, there have been however many examples already given, and many more might easily be added, and they have taken place exactly at the period of the boulder clay, which, of all parts of the boulder formation, is the richest in large blocks. It is therefore highly probable that these boulders of the old rocks have not travelled from Sweden, but have been broken and torn off from a great mass of granite which was actually *in situ*, and this result is the more probable if it is considered in what way the Scandinavian granitic chain disappears in Sweden beneath the newer formations, being first partially capped with fragments of chalk and afterwards lost sight of entirely under the boulder clay towards the S. W.; the granitic gneiss, however, re-appearing at intervals, and generally at a lower level. It is worthy of notice also that this boulder clay with large blocks only appears extensively in the eastern part of the country, in connection with the Brown coal formation just in that spot in which the strata of this latter series are often vertical, and seldom less inclined than at an angle of 45°, whilst the more re-

gularly lying Brown coal series of Western Jutland is seldom covered with the boulder clay, and then only at intervals. Now, since also in the only place in the western system where we know of the existence of greatly inclined strata of the Brown coal series, namely, on the island of Sylt, it is also covered with a thick bed of boulder clay : it appears clearly made out that the cause of the deposit of this bed was identical with that which has disturbed the strata of the Brown coal series. With reference to this point it is also not unimportant to notice that the boulder clay of Sylt contains so many fragments of true lava, that the inhabitants of the island have remarked it, and designated it by the name of *Bimmstein* (pumice). Carrying out this view, the presence of calcareous and schistose fragments of the old rocks, in several spots where they are so common that attempts have been made to reach the supposed subjacent rocks themselves, is an important fact, since it would seem to point to a possible continuation of the silurian rocks, which we are enabled to trace from the lake of Ladoga as far as Bornholm.

The last member of the boulder formation consists of sand and rolled fragments, and I have called it the "boulder-sand-formation." Sometimes the sand is argillaceous, but I have not observed true argillaceous bands in the formation itself, although it is sometimes overlaid by a brown clay without calcareous matter which formed the last precipitate, if I may so say, after the greatly disturbed ocean had at length become calm. This formation (the boulder-sand) is always stratified, but the strata are generally highly inclined, much curved, sharply broken off, and in a word resemble those strata which the greatly disturbed waves now deposit on our coast. The surface of the country where this formation prevails is much varied, and consists sometimes of complete chains of hilly ground greatly inclined on both sides, and perfectly resembling in that respect the Swedish *Aosar*, but analogous also to the so-called *Revler* on the west coast of Jutland, where parallel banks of sand and stones are separated from one another by the sea at high water. Another form in which this formation presents itself (seen in North Seeland and North Jutland), is that of a hilly sandy district, without the hills having any distinct direction ; and a third form exhibits hemispherical hills, some a hundred feet high and near together, the valleys being merely the spaces between several of these segments of spheres. This latter form is seen on the Cape, at the Cattegat, and in the island of Samsøe, and a fourth form is observable on the peninsula, where a thin covering of this part of the series rests on the level expanse of the Brown coal formation.

Large boulders are not found in this formation ; the solid content of those that occur being seldom so great as two cubic feet, while all of them are completely rounded, and they are sometimes so numerous that the sand only fills up the interstices between them ; while on the other hand, the sand occasionally forms so large a proportion of the whole mass, that there are only a few boulders to

be seen, sparingly distributed through it. It appears in many places that the boulders of this sand are only the result of the disintegration of the boulder clay, the proportion of rocks of different kinds being almost exactly the same; and hence it results that the current which formed this newer bed brought few or no materials with it, merely reconstructing in a somewhat different form the rocks over which it passed.

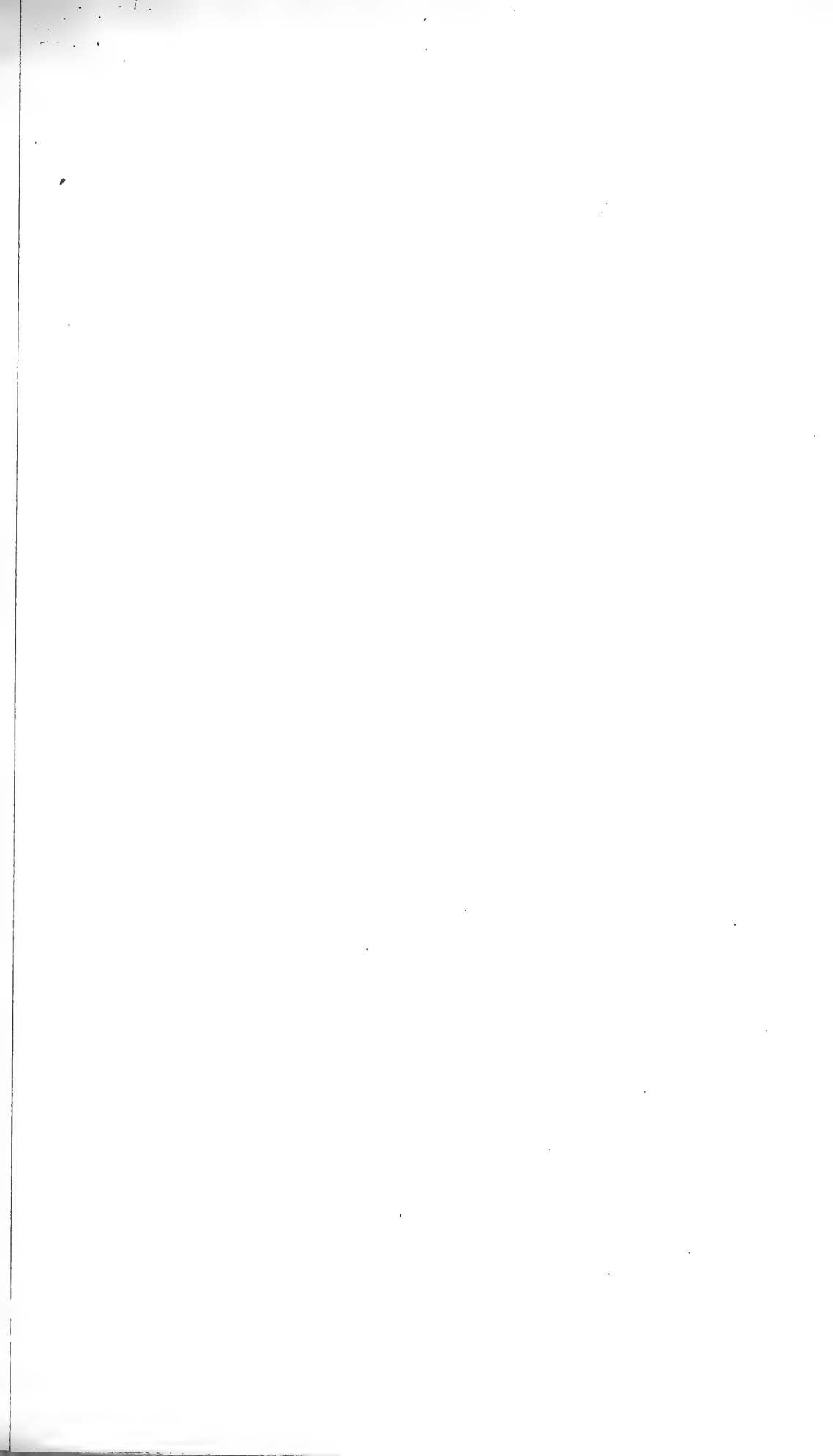
The boulder sand contains, here and there, fossil remains of several species, all of which are still common on the coast of the North Sea. Near Svendborg in South Fühnen, I met with *Buccinum reticulatum*, and near Tarbeck in middle Holstein there is an oyster bank where with *Ostrea edulis* are associated *Cardium edule*, *Littorina littorea*, and *Buccinum undatum*.

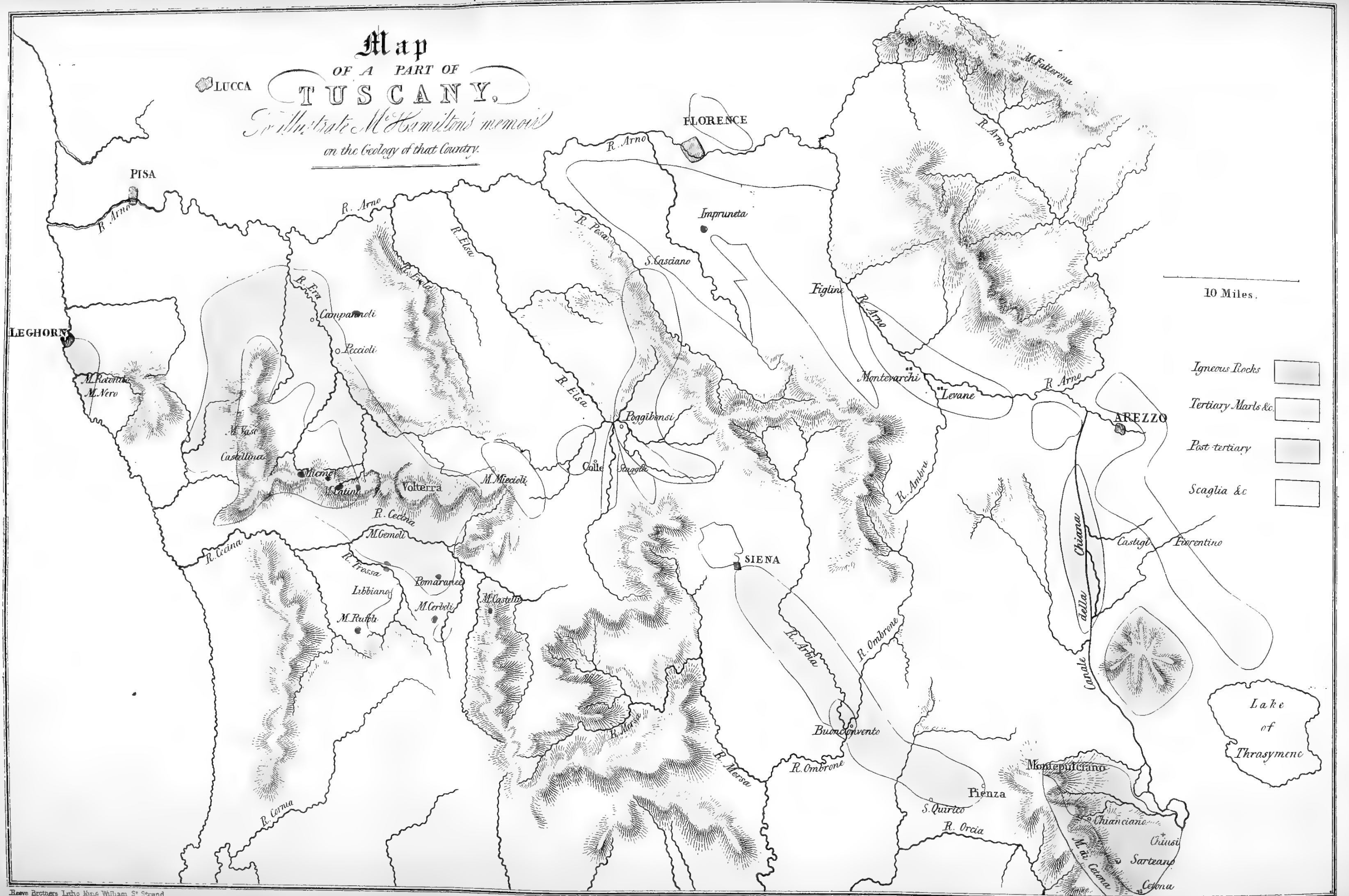
Just as the sandy plains and ranges of sand hills appear in Denmark, they are also found in middle and southern Sweden, and there they sometimes appear as thick horizontal layers of sand, which by subsequent marine action have become converted into chains of low hills; and sometimes they form more decided and higher hills, of which the great *Aos*, which extends from above Upsala to Stockholm, nearly parallel to the coast of the Gulf of Bothnia, is an instance sufficiently remarkable from the undulating appearance of the strata of which it is composed.

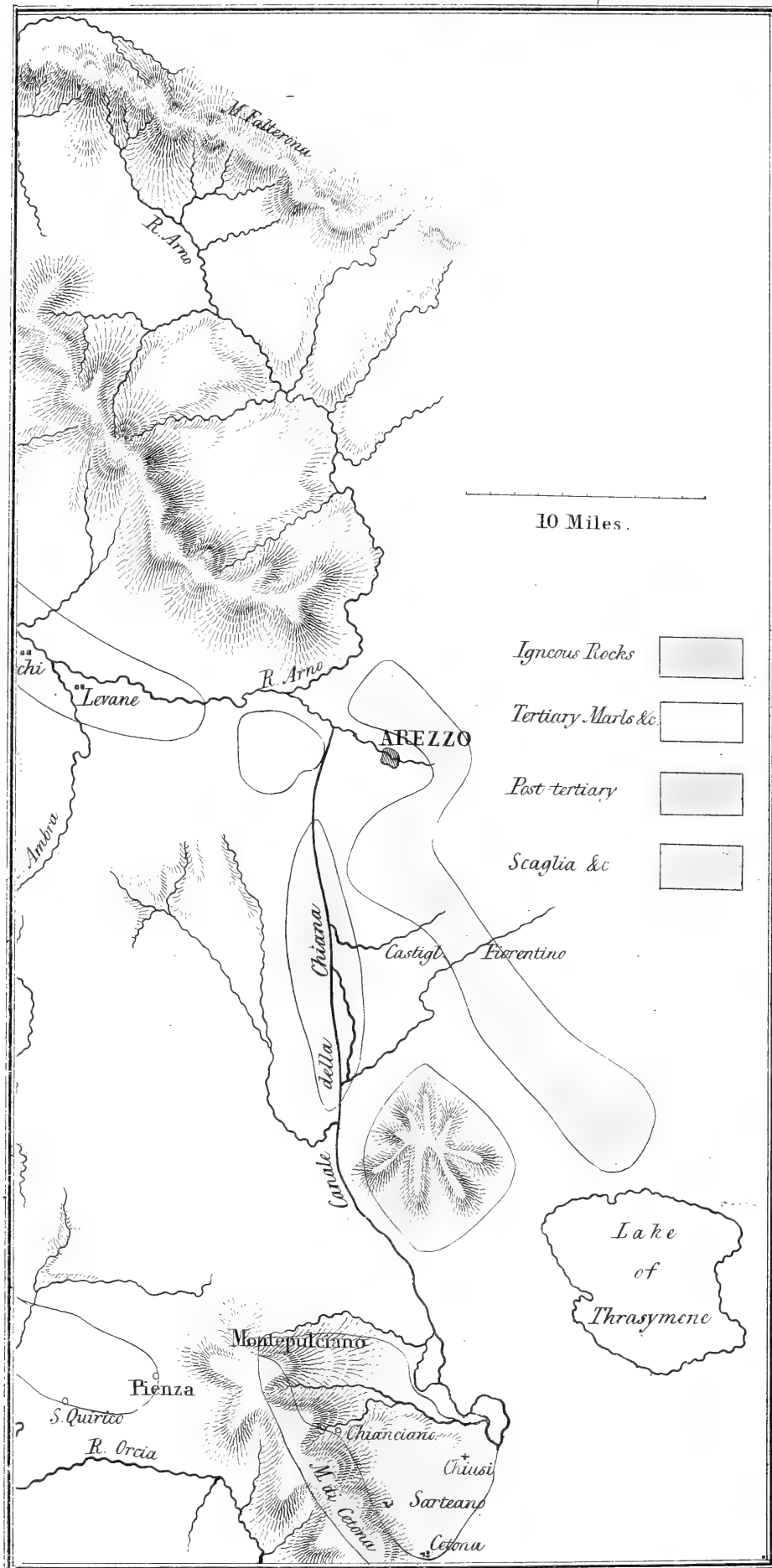
Many sections, both on the coast and in the interior of Sweden, exhibit the sequence of these beds. The clay, the base of these sections, contains the *Mytilus edulis*, indicating the presence of the sea at the time when the formation of the *Aos* commenced. Upon the clay there rests a bed of sand exhibiting false undulating stratification in layers 25° E., and then succeeds a horizontal layer of small stones washed from other beds; and lastly, vegetable mould. I believe there will be found sufficient proof that the Swedish *Aosar* were all formed in the same manner as the Danish, and without doubt, at the same period, and by similar agency.

D. T. A.

[M. Forchhammer then enters on the consideration of the various theories that have been suggested to account for these phenomena. A notice of this part of the paper will be given in the next number of the Journal.—ED.]







THE
QUARTERLY JOURNAL
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THE GEOLOGICAL SOCIETY OF LONDON.

I. PROCEEDINGS
OF
THE GEOLOGICAL SOCIETY.

NOVEMBER 6. 1844.

THE following communication was read:—

OBSERVATIONS *on the GEOLOGY of some parts of* TUSCANY. By
W. J. HAMILTON, Esq. M.P., Sec. G. S.

ONE of the principal physical features of the district under consideration in the present memoir, is the existence of three distinct mountain ridges, extending from N.W. by N. to S.E. by S., and parallel to the direction of the main chain of the Apennines. All these ranges belong to the *Scaglia*, a representative of the cretaceous series which is known to prevail extensively throughout Greece, the Morea, the Ionian Islands, Asia Minor, and the South of France.

I cannot pretend to define the limits of these different ranges, or even to point out their exact number and geological contents, having only been able to visit a small portion of them; but the following are the principal lines occurring in the district which came under my consideration.

1st. The first line, commencing between Pistoja and Prato, passes through Castello and Fiesoli, and keeping to the N.E. of Florence, descends in a S.E. direction to Arezzo, Castiglion Fiorentino, Cortona, &c., when it passes to the N.E. of the Lake of Thrasymentine.

2d. Commencing to the S. of Pistoja in the Monte Albano, the second line crosses the Arno, between Signe and Empoli, and passing through Galluzzo and L'Impruneta, extends through San Martino, San Donato, Incisa, Levane, to the hills of Chianti, and thence to Monte Cetona.

3d. The third line, more to the S.W., may be said to commence with the hills of Monte Pisani, near Pisa; thence crossing the Arno, it continues along the line of hills which separates the valleys of the Era and the Elsa, passing between Volterra and Poggibonzi until it reaches the mountainous district, in which are the quarries of Sienna marble, ten or fifteen miles S.W. of that city.

Perhaps a 4th parallel line may be traced further to the S.W., commencing with the hills of Monte Rotondo, near Leghorn, and passing through Monte Catini and Monte Cerboli, until it loses itself in the complicated system of the Maremma.*

It is still a question for further investigation how far the crystalline limestone near Sienna, and in which, to the W. and S.W. of that town, are the quarries of Sienna marble, is to be considered as a district of older formation. It is probable that a transverse chain of elevation, marked by rocks of a more crystalline character, will hereafter be distinguished extending from N.E. to S.W., *i. e.* from the Monte di Chianti, through Monte Maggio, N. of Sienna, to the district in which the quarries occur.

The valleys between these different ranges are generally filled with tertiary deposits of various characters, some of a mere local nature, while others extend over a considerable tract of country, to which they impart a singularly dreary appearance, being almost entirely devoid of vegetation and altogether unsuited for cultivation.

The various formations of Tuscany may be described in the following ascending order: —

A. STRATIFIED ROCKS.

I. Secondary formation.

- II. Tertiary formation { 1. Tertiary marine.
2. Tertiary freshwater.
3. Post-tertiary formations.

B. METAMORPHIC ROCKS

Red Gabbro.

C. IGNEOUS ROCKS.

1. Serpentine — secondary period.
2. Selagite — tertiary period.
3. Basalt of Radicofani, &c.

* Since writing the above, I find that the same features of three parallel ranges have been described by M. A. Burat, in a paper lately read before the Institut de France. See *Comptes Rendus*, 1843 (p. 1279.).

A. STRATIFIED ROCKS.

I. *Secondary Formation.*

These rocks, which constitute by far the greatest portion of the mountainous districts of Tuscany, forming the parallel ranges extending from N.W. to S.E., consist of various beds of sandstone, indurated marls and shales, and compact grey lithographic limestone or scaglia, either alternating with each other or more or less developed in different localities.

The sandstone consists of three different varieties, viz., —

(a) Hard grit (*macigno*), considerably developed near Florence, particularly to the W. and S.W., where it forms large mountain masses, and is extensively quarried along the banks of the Arno, and at various other points, for building-stone and for the slabs employed in paving the streets of Florence. A very considerable quarry, affording an excellent section of thin beds of this rock, alternating with a soft bluish shale, occurs on the banks of the Ema, near Ponte d'Ema, about two or three miles S.E. from Florence. Many of the slabs show slight appearances of fucoidal stems. It generally occurs alternating with thin bands of shale of a dark blue or reddish colour. It varies considerably in dip, although most frequently inclined to the N., N.E., and N.W. The grain of this stone is generally coarse and compact, and it is often traversed by thin veins of calcareous spar.

(b) A fine-grained greenish sandstone (*pietra serena*), extensively quarried near Fiesoli, where the beds dip to the N.W., and used for architectural purposes in Florence. It also occurs at Monte Catini, just above the village of that name, dipping S. and S.E.

(c) A soft friable sandstone, of a yellowish brown colour, slightly micaceous. It is broken by numerous fissures into rhomboidal masses of various sizes and shapes. It forms hills of considerable height and extent in the Val d'Arno di sopra, above Levane and Arezzo. I only met with one locality producing anything resembling organic remains, and these consisted of a few vegetable impressions.

The indurated marls and shales are generally associated with the hard grits and sandstones; but the former are sometimes developed to a great thickness, forming masses of considerable extent, and consisting of numerous strata. This formation came under my notice in the vicinity of Castiglion Fiorentino, between Arezzo and Cortona, and in the neighbourhood of the mines of Monte Catini. In the former locality it is traversed by several thick veins of calcareous spar; and in the latter it consists of a great variety of thin strata, dipping from the region of the copper mines to the S. and S.W., and underlying a thick formation of secondary lithographic limestone. Numerous beds of indurated shales also

occur in the neighbourhood of Florence, in the hills above the Certosa, where it is overlaid by thick beds of macigno.*

The limestone called in the country *alberese*, and often associated with the above-described sandstones and indurated argillaceous shales, is very compact, varying in colour from a bluish to a yellowish white, and resembles lithographic limestone and the scaglia of the N. of Italy and Greece, which is generally referred to the Cretaceous period. The principal localities at which I had an opportunity of observing it were : 1, near the Impruneta, six or seven miles S. of Florence, where it is extensively quarried. Not far from hence, at a place called Mugnano nummulites are said to have been found in great abundance in one of the limestone beds ; 2, at San Donato, 9 miles S. E. of Florence, on the road to Arezzo, where it forms hills of considerable height. It is either horizontally stratified or dips slightly to the E. It may be traced for several miles to the S. in the bottom of all the ravines, overlaid by tertiary sands and gravels, as far as Incisa, on the banks of the Arno ; 3, at Monte Catini ; the *alberese* here overlies the sandstone and indurated marls which have been upheaved and tilted by the protrusion of the igneous rocks with which the copper mines of La Cava are connected. It laps round the uplifted masses of Monte Massi and Poggio alla Croce, and not possessing the same elasticity as the schistose beds, has been much more shattered and broken up by the elevatory action to which it was exposed. It also occurs in the same chain of hills further westward, towards Monte Miemo, where, not being in such immediate contact with igneous rocks, it still preserves its compact and stratified character. Proceeding westward, towards Castellina, it is found in several places near Monte Vaso, where attempts are now making to obtain copper on the strength of indications similar to those of Monte Catini.

To the S. of the Cecina, in the midst of a wild and wooded mountain district, consisting chiefly of serpentine or ophiolitic rocks, the same scaglia limestone also occurs, forming elevated plateaux and ridges, on which, notwithstanding the enormous fragments by which the ground is encumbered, the industry of the inhabitants is constantly directed to the raising of crops of corn. My attention not having been so particularly directed to these secondary formations, I regret that I cannot more clearly describe the different groups into which they are subdivided.

II. *Tertiary Formation.*

The tertiary formations of Tuscany may, for the purposes of arrangement, be subdivided into three groups, as already mentioned :—

* Captain Portlock's paper has been communicated since this was written.

1. TERTIARY MARINE FORMATION.

The principal localities in which I observed this formation may be referred geographically to the following districts : —

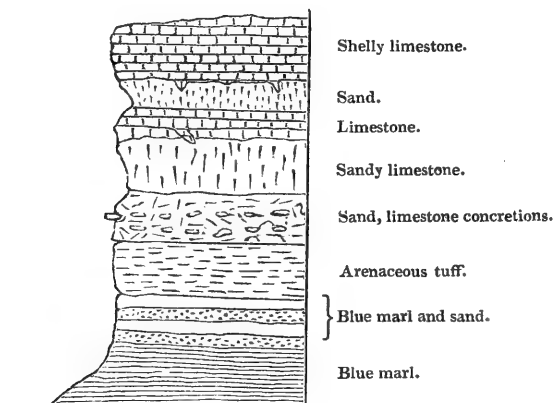
- a. The basin of Volterra and its neighbourhood, with the valley of the Era.
- b. Leghorn.
- c. Poggibonzi, including the country from Colle to S. Casciano, with a great portion of the valley of the Elsa.
- d. Sienna, and the country watered by the Ombrone, extending to Buon Convento, S. Quirico, and Pienza.
- e. The upper portion of the Val di Chiana, and the basin containing the lakes of Chiusi and Monte Pulciano.

a. The Basin of Volterra and its neighbourhood, with the Valley of the Era.—This district commences on the north with the hills which form the southern boundary of the Val d'Arno, near Ponte d'Era, and extends S.S.E. as far as the Cecina, where it constitutes a range of hills on the south bank of that river, resting against a confused district of serpentine and scaglia limestone. On the east it is bounded by the hills which separate the valleys of the Era and the Elsa, and which, where I had an opportunity of seeing them, consist of secondary limestone ; and on the west by the hills to the S. E. of Leghorn, of which the highest point is known by the name of M. Nero. In the S. portion of this region rises the insulated mass of hills extending from E. to W., from M. Catini to Castellina, and which is thence prolonged northwards to M. Vaso. These hills consist of the secondary formation already described, lapping round masses of gabbro rosso and serpentine ; this latter rock has protruded itself in many instances, and with it the metalliferous deposits of this district are mainly connected.

The beds of which this tertiary formation consists rise gradually from the N.W., from under the alluvial formation of the Val d'Arno, towards Volterra, where they attain a height of nearly 1800 feet. By far the greater portion of the whole thickness is a stiff blue clay, called by the inhabitants *matajone*, throughout which are disseminated many small crystals of selenite. It first appears at the foot of a lofty cliff on the right bank of the Era, called Ripa Bianca, under the village of Peccioli. It is overlaid by a thick bed of sands, limestone, and arenaceous tuffs, varying in thickness from 20 to 100 feet, the lower portions of which are very friable, and contain many small calcareous nodules, arranged in parallel layers. On the left bank of the Era, near Capannoli, I observed in the sand several parallel beds of oysters, thickly matted together, and associated with a few broken Pectens.

The summit of the lofty hill of Volterra, affording one of the most commanding positions in the country, and remarkable as being the site of an old Etruscan city, gives another interesting section of the limestone and arenaceous beds, which cap the ter-

tiary blue marls ; the total thickness of this capping is about 80 or 100 feet. This elevated plateau is nearly 2000 feet above the level of the sea. To the W. and N.W. it presents a long extent of steep escarpment, 80 or 100 feet high, near the northern extremity of which is a deep and precipitous ravine, called Le Balze, in which extensive land-slips are constantly taking place, and where, during the last 150 years, many houses and churches have been engulfed by the gradual working back of the cliff. A spring of water issues at its foot, between the sandstone and the blue marl, which, acting on the lower arenaceous beds, combined with the effect of weathering and heavy rains on the blue marl itself, has undermined the cliff, and caused its fall into the hollow below. The following is a section of this part of the formation : —



The upper bed of shelly limestone is full of *Cardium*, *Pecten*, *Ostrea*, &c., but in a very comminuted state. In the arenaceous beds they are less abundant, but the nodules or calcareous concretions are full, and in fact are sometimes quite composed of them. In some places the separation of the limestone from the sand is not complete, and the whole bed consists of an arenaceous limestone. At a short distance from Volterra to the E. S. E. is another hill called Poggio alla Rocca, consisting, like the former, of blue marl capped with limestone and arenaceous beds, but not rising to the same height. Marine fossil shells are very abundant in many parts of this formation.

This upper formation or capping is evidently a portion of that which, occurring on the summit of many hills in this district, has received from Savi the name of *Panchina*, and which he considers as the result of local submarine springs depositing calcareous matter in the neighbourhood of their sources. But it is of so general a character, and occurs in so many districts under the same circumstances, that I cannot agree to such a partial explanation. Many of the hills S. of the Cecina, and particularly in the neigh-

bourhood of Pomerance, are capped with thick beds of this same calcareo-arenaceous deposit. Pomerance itself is built on a mass of it, and it closely resembles that which I shall hereafter describe in the Sienna district, and on which the towns of S. Quirico, Pienza, and Sienna are also built; although here it is perhaps rather more calcareous. It also occurs to the S.E. of Leghorn, where it forms the substratum of the plain and the beach. It is, however, certainly a remarkable feature that it is seldom quite horizontal, but appears to follow the slope of the hills, lapping over them like a covering. It everywhere contains numerous marine shells, chiefly *Pecten* and *Ostrea*; the latter sometimes constituting whole beds, while the material is in many places sand and pebbles, with a hard calcareous matrix. Although this formation is always found as a capping of the hills, and never occurs in the valleys, it is not seen on the high hills of Monte Catini and Monte Vaso, which were probably already elevated into islands before it was deposited; but it may, I think, be traced in a few places circling round the eastern portion of these hills, opposite Volterra. Of these the localities most worthy of observation are where the new road leading to M. Catini and La Cava has been cut through thick beds of conglomerated pebbles, sand, and calcareous bands containing large *Ostrea* and *Pecten*, and evidently resting against the unconformable beds of the secondary formation, and of the gabbro rosso.

But the most extensively developed feature in this marine tertiary formation is the blue marl which immediately underlies the last-mentioned beds, and has in the great basin of Volterra a thickness of nearly a thousand feet. It may, however, be a question whether this blue marl does not belong to an older tertiary period, — Eocene, perhaps, instead of Miocene, as the limestone capping, instead of being almost horizontal, generally follows the slopes and undulations of the hills, as if deposited after the valleys had been scooped out.

At Volterra fossil shells are of rare occurrence in the blue marl; but as we approach the borders of the formation towards the north, they become more abundant, and in some cases, as near the junction of the Sterza and the Era, may be said to constitute nearly one half of the whole mass of the formation. They are, however, so broken and fragile, that it was difficult to extract entire specimens. *Dentalium*, *Cardium*, *Venus*, *Cerithium*, *Pleurotoma*, *Turritella*, and large *Ostrea*, were most numerous. With them were associated small crystals of selenite, which, abounding in many portions of the blue marl, give it a glittering and sparkling appearance.

Below the borgo of Monte Catini is found a singular spotted argillaceous rock, resting against the erupted mass of igneous rock on which Monte Catini is built. Its appearance is that of a trap rock; but, on further search, it proved to be full of shells, chiefly *Cardium*. It is of a greenish grey colour, and at first shows

a few light-coloured spots, which, by degrees, become more numerous, and occur even in the shells themselves. Other specimens, in which decomposition or alteration is more advanced, show larger spots; until at length they assume an entirely pisolitic character, the grains being perfectly detached, whether they occur in the mass of the rock itself, or in the shells. I believe it to be the blue marl altered by the eruption of the igneous rock.

But if the blue marl near the centre of the basin is deficient in organic remains, it abounds in numerous productions of mineralogical importance, which, both from their own intrinsic value, and from their connection with other phenomena still occurring in the same vicinity, deserve to be particularly noticed.

About five miles S.S.E. from Volterra, in the deep valley of S. Giovanni, situated in the blue marl, and watered by a small stream, are extensive salt-works, now the property of the Government, but from which, in former times, the inhabitants of Volterra chiefly derived those riches by which their town flourished and preserved its independence and importance. These salt-works are fed by springs of brine collected from nine different spots where the saturated water is pumped up from deep pits. It has been ascertained by sinking wells and by Artesian borings that this brine is derived from beds of rock salt, which, at different depths below the surface, varying from 50 to 100 feet, are found alternating with the blue marl, in the same manner as the alabaster occurs in other parts of the same formation; and in the boilers, during the process of evaporation, much sulphate of lime is deposited. The average annual production of salt is stated to be from 18,000,000 to 19,000,000 Tuscan pounds;—about 140,000 cwt., or 7000 tons per annum.

The other productions found in the blue marl are gypsum, alabaster, and selenite, — the various forms in which the sulphate of lime so abundant in this district has been deposited. They are particularly met with in the neighbourhood of Volterra, where, however, all the varieties of gypsum do not occur. The pure white quality known as alabaster, and in such demand at Florence, is only found in the neighbourhood of Castellina, about twenty miles W. N. W. from Volterra, at the western extremity of the hills of Monte Catini. It may, however, be observed that the great developement of gypseous matter appears to be confined to a narrow line extending from W. N. W. to E. S. E., in which direction a band of only a few miles in width drawn from Castellina to somewhere near Monte Miccioli would comprise all the gypsum and alabaster quarries in the country, as well as the salt-works already alluded to.

The deposits of Volterra, Picchiaiola, S. Lorenzo, and Castellina may be described as giving the best types of the different forms in which the gypsum of this country occurs. 1. That of Volterra, which is called the variegated alabaster, is most frequently found in detached irregular masses of greater or less size, penetrated by red

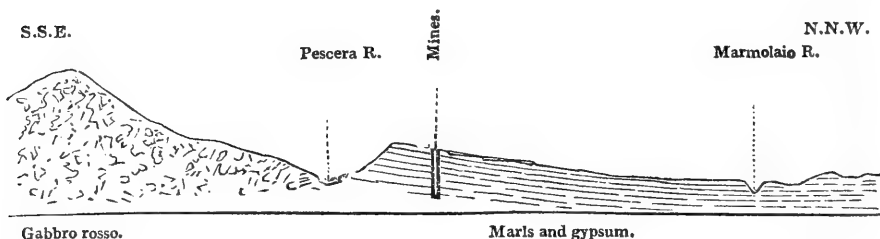
and green and yellow veins. It is frequently much shattered, and sometimes mixed up with the blue clay: it is harder than the other varieties, and is used principally in the manufacture of vases, candelabra, &c. It occurs chiefly from four to six miles S. E. and E. of Volterra, on the road to Florence.

2. In the immediate vicinity of the little village of Picchialiola, five miles on the road from Volterra to Florence, is a very considerable mass of gypsum of peculiar character, rising above the surface of the ground. It consists of irregularly compacted masses of crystals of selenite easily detached from one another, and called by the people of the country *specchio d'asino*, or the "ass's looking-glass." On breaking off the outer crystallised crust, an earthy crystalline substance is perceived full of cavities and botryoidal concretions, precisely resembling the substance formed round the vents of the vapours of Monte Cerboli; at once suggesting the idea that some at least of these gypseous deposits may have been produced by similar vapours or *soffioni*.

3. The third form in which the gypsum occurs in this district is that of an irregular broken stratification. The blocks occur at intervals more or less distant, extending in long lines through the marls in which it is found, sometimes occurring as detached masses, and at others in continuous beds. In the neighbourhood of S. Lorenzo, near the suspension bridge over the Cecina, this formation is seen on both sides of the river, but is not of any great thickness. Near Buviano, on the north bank of the Cecina, towards Monte Catini, the gypsum beds occur sloping at a very considerable angle down the hill sides, and apparently following their inclination. Wherever this variety of gypsum occurs it is almost invariably of an opaque white saccharine character. It is found in many detached spots in the Volterra district.

4. By far the most interesting and important of the different varieties of gypsum is the fine white alabaster found in the neighbourhood of Castellina, where it is regularly stratified, and is worked in properly constructed mining galleries. The little town of Castellina, distant about twenty or twenty-four miles from Volterra, is reached by a rocky road over wild and rugged mountains. It is situated on the W. N. W. slope of the hills of Monte Vaso, overlooking in that direction an extensive and slightly undulating plain of tertiary marls, which there can be no doubt extend round the north point of the Monte Vaso chain, and are connected with those of the Val d' Era and the Volterra district.

The mines are situated three miles W. N. W. from Castellina, near the edge of the tertiary marls, where they rest against the secondary rocks. They occur on a slightly rising ground between two streams, the Pescera on the south, which flows between it and the hills, against which the blue marls probably once rested before the river bed was washed out, and the Marmolaio on the north, which flows through the marl itself. (See Section, No. 2.)



The beds have, at the mines, an inclination of about 5 degrees to the N. W. or N. N. W., and consist of regularly alternating strata of blue clay or matajone and grey gypsum, the latter containing in regular layers nodules or spheroidal blocks of the pure white alabaster. In the shaft of the mine I observed five distinct beds of gypsum alternating with the blue clay, and varying in thickness from five to twenty feet; but as the owner, Signor Mazzoni, had no measurements, and I had no means of obtaining perfect accuracy, the numbers are probably understated. The only known measurement was, that the whole depth of the shaft to the fifth bed of gypsum was 110 braccie, or 200 feet, and in another mine the fourth bed, which was here 20 feet thick, was there said to have a thickness of 30 feet.

The range of low hills in which the alabaster is found, is about four miles in length along the strike of the beds from N. E. to S. W., but the pure alabaster is only found near the centre of this line, and three of the four mines now worked are on the small property of Signor Mazzoni: nor does it extend far in the transverse direction from S. E. to N. W., for about half a mile N. W. the gypsum is of a very inferior quality, and dips under the blue marl; and the mines, though sunk to the depth of nearly 200 feet, are rendered useless by the water having got in.

We entered the mine by an inclined path, and, passing under ground, soon reached an open well or large inverted cone, round which the inclined path is carried, and where the section of marls and gypsum is well exposed. As the descending road passes through the third and fourth gypsum beds, galleries are seen striking into the rock in all directions. The first and second gypsum beds are of a uniform character and grey colour, and do not contain any alabaster blocks. These are found principally in the third and fourth beds, and occur as irregular isolated spherical masses imbedded in the gypsum, from which they are, mineralogically speaking, distinctly separated by a thin black crust, which indicates to the workman the existence of the finer nodules. These nodules are most frequent in the lower part of the stratum, and occur in regular layers, never touching, although varying much in their distances from each other. In bed No. 3. there are two layers of these nodules, and in No. 4. there are three. They vary much in size, weighing from 20 or 30 lbs. to upwards of 2000 lbs. When the workman discovers the black crust, he is at once aware

that he is near a block of alabaster, and by following the direction of the crust, he removes the gypsum all round until he has nearly detached the whole nodule, which is at last carefully separated from the parent rock. Gunpowder is occasionally used to blast the rock when no black crust indicates the existence of the alabaster. This crust in connection with the pure alabaster is perhaps one of the most curious features of the mine. On close examination it appears to be laminar and concentric, and to consist of layers of blue clay and gypsum. Now the whole formation of gypsum contains a small portion of clay which gives it the greyish colour, and it is probable that, when that peculiar principle, whether crystallisation, attraction or electricity, which caused the aggregation of the particles of gypsum in greater purity and in a more crystalline state was in operation, one of its chief effects was to expel to the circumference all the particles of argillaceous matter previously mixed up with the gypsum; a process which would continue until either the crust itself opposed a resistance to the further action of this principle, or until two opposing spheres nearly came in contact with each other. Very fine crystals of selenite, and sometimes of a large size, are not unfrequently found in the fissures of the gypsum. They are used for the purpose of making the fine Scagliola cement, and are consequently sold at a much higher price than the more ordinary gypsum. The price of the fine alabaster is 5 Tuscan lire the 100 lb. Tuscan at the quarry, or 8 if delivered in Leghorn.

b. Leghorn. — The plain immediately to the S. E. of Leghorn consists of a hard calcareous rock in horizontal beds extending from the mountains to the sea-shore and even into the sea, forming sometimes the low flat beach, and at others the broken cliff above. It is generally very compact and hard, and not unfrequently contains pebbles of alberese and other secondary rocks, and also a few marine shells. It appears to belong to the formation of arenocalcareous rocks, which caps the summit of the Volterra and other hills, and has received from some of the Italian geologists the name of Panchina.

c. Poggibonzi. — The third district in which marine tertiary deposits are found is that of Poggibonzi, including the country from Colle to San Casciano, with a portion of the valley of the Elsa and of the Pesa. I have made this a distinct district from that of Volterra; because it appears to be entirely cut off from it by a chain of hills of secondary formation: geologically speaking, it is probably a portion of the same district. It consists, in its western portion, of thick beds of yellow sand; while towards the N. E., and particularly towards the north, and near San Casciano, it becomes gradually more gravelly, and, at length, consists almost entirely of thick banks of pebbles, increasing in size towards the north as they approach the rocks of the secondary age against which they rest, and from the breaking up or wearing away of which they were, in

all probability, derived. On most of the hill tops, oyster beds and pectens of large size are found. In some of the deep ravines and glens, beds of blue marl are perceived underlying the sands and gravels, but not developed to any great extent or thickness. Near the 21st mile from Florence, extensive beds of blue marl are seen in the ravines N. W. of the road, with a perfectly horizontal line of separation between them and the overlying sandstones. In general, however, the whole surface of the hills, the summits, and the valleys are covered with the sands and conglomerates; and it is still doubtful whether or not the valleys were already hollowed out in the blue marl previous to the deposition of the sands and gravels on its undulating surface. I am rather inclined to adopt this view, as in the deep valley of the Pesa the great masses of overlying gravel and conglomerate reach to the bottom of the valley, and much lower than where the blue marl occurs in other places. At all events, we may trace from San Casciano to Poggibonzi, and perhaps even to Volterra itself, a gradual change in the form of the various elements deposited during the tertiary epoch; indicating a greater facility of being held in suspension and transported by water: although, perhaps, this will only apply to that portion of the formation which overlies the blue marls. Near San Casciano, beds of conglomerate abound. As we proceed S., the pebbles become smaller, and gradually disappear, being replaced by a fine compact arenaceous tuff, which occurs in the neighbourhood of Poggibonzi and Colle; and further S. and S. W., the upper beds become still finer and of a more comminuted character.

d. Sienna District.—The fourth district of the tertiary marine formation commences a little to the north of Sienna, and extends, in a S. E. direction, through the country watered by the Arbia and the Ombrone by Buon Convento to beyond San Quirico and Pienza. Its southern limits I did not ascertain; but to the N.E. it is bounded by the secondary hills which separate it from the Val di Chiana and the district of Monte Pulciano. It consists, for the most part, of blue clay or marl, remarkable for its sterility and bleak appearance. It contains, here and there, a few crystals of selenite, but a most careful search, in numerous localities, did not produce a single fossil shell. In many places it is capped by beds, varying in thickness, of yellow arenaceous limestone and sand, some of which are full of marine testacea, constituting entire masses of *Ostrea* and *Pecten*.

These elevated table lands, wherever I observed them, have in early ages been invariably made use of by the inhabitants, as affording safe foundations for their cities, which would be sought for in vain on the soft and yielding masses of the subjacent marl. On such table lands are built the towns of Pienza, San Quirico, Montalcino, Sienna, and probably many others. Pienza is situated near the extremity of a narrow, rocky, peninsula, of which the upper bed consists of a compact, agglomerated, calcareous sandstone, having a slight inclination to the S.W. Immediately below

it, and overlying the blue marl, is a more sandy bed, of no great thickness, full of broken shells, chiefly two species of *Ostrea*.

San Quirico stands upon a similar table land, the only difference being that several beds and layers of conglomerated pebbles, chiefly consisting of the white *alberese* or Scaglia limestone, are associated with the sandstone tuff.

e. Val di Chiana. — The fifth district is the upper or southern portion of the Val di Chiana, and the basin, containing the lakes of Chiusi and Monte Pulciano, extending to the frontiers of the papal dominions, near Città della Pieve. A portion of this district, low as it is, is remarkable, as constituting, since the great hydraulic operations undertaken by the Tuscan Government, the watershed between the drainage flowing into the Arno and the Tiber. Two miles to the south-east of the town is the Pian della Biffa, formerly a marshy lake, across the centre of which is a dyke called L'Argine della separazione, on the respective sides of which the waters flow to the Tiber and to the Arno, sluice-gates being placed at each end to regulate the escape of the water in the spring, and to prevent the plains below, particularly on the banks of the Tiber, from being flooded.

My geological observations in this plain were chiefly confined to the neighbourhood of Chiusi and the north-east flanks of the range of hills on the west side of the plain, from Cetona to Monte Pulciano. The hills round Chiusi, on one of the highest points of which the town is built, consist of numerous alternating beds of gravel, conglomerate, sandstone and blue marl; some of these beds, particularly the latter, and occasionally the sandstone, contain numerous marine tertiary shells. In some, complete oyster beds are still preserved, forming large masses of shells of considerable thickness, which are particularly developed near the lake to the east of the town. Here I observed, in an ascending order, the following section :—

1. Sandy tuff, or friable sandstone, of very great thickness, sometimes containing intercalated beds of gravel. In the so-called tomb of Porsenna, two or three miles north-east from the town, is a band of gravelly conglomerate in this sandstone tuff, which has been made use of to form the flooring or separation between two tiers of excavated tombs or chambers. Most of the well-known Etruscan tombs in this neighbourhood are excavated in this rock, which does not contain any fossils.

2. Blue clay, a few feet in thickness; organic contents uncertain.

3. Reposing on the blue clay is a very thick, solid bed of oyster shells, in which are some of a most diminutive size.

4. A thick bed of gravel and conglomerate, strongly cemented together by a calcareous paste. This is, in many places, of very considerable thickness, forming the capping of the hill on which the town of Chiusi is built, as well as of several other eminences in the neighbourhood. On an estate belonging to the bishop, near

the tomb called "tomba della vigna grande," the series of beds was rather different.

In a ravine, one mile north-west of the town, the blue clay is well exposed, and is of considerable thickness. In it numerous shells are found — *Cerithium*, *Serpula*, *Dentalium* (2 sp.), *Venus*, *Cardium*, *Arca*, *Pecten*, *Natica*, *Pleurotoma*, *Cancellaria*, *Nassa*, and others. The same clay beds are well exposed on the road to Cetona; and, again in the neighbourhood of Sarteano, equally rich in marine testacea. Between Sarteano and Chianciano, *Cardium* is found in the sandstone tuff. Chianciano is celebrated, in the annals of Italian Geology, for the great abundance and variety of its tertiary marine shells, which occur in one or two localities near the town.

From Chianciano the same tertiary formation extends to Monte Pulciano, offering sections of gravels and sands, containing beds of oysters. Monte Pulciano itself stands on a lofty insulated hill of sandstone and gravel. In the sand are many large *Ostreæ*, and a few *Cerithia* occur in the nodular calcareous concretions. The formation is traversed by a few almost horizontal beds of very hard sandstone. To the north of Monte Pulciano is the commencement of a bleak and arid blue marl district, resembling that so remarkably developed in the neighbourhood of Pienza and S. Quirico, and with which the district of Monte Pulciano and Chiusi was, in all probability, formerly connected.

2. TERTIARY FRESHWATER FORMATION.

I now proceed to describe those localities in which tertiary freshwater formations came under my observation.

On the range of hills which I have been just describing, between Cetona and Sarteano, the road crosses a spur of limestone rocks, which, from its compact character, colour, and honeycombed appearance, I at first attributed to the Scaglia formation of the secondary or cretaceous period. But, on reaching the summit of an elevated table land, I found in it numerous tertiary freshwater shells, as *Planorbis* and *Limnæa*. It rests against the secondary rocks, and appears to be overlaid by the blue marls containing marine shells.

Another locality, where the same rock occurs, is in the valley of the Bultino, two or three miles south-east of Colle, on each side of which are extensive remains of a tertiary lacustrine formation, through which the valley has been cut, and a large plain has been excavated. The lower beds are very arenaceous, and contain calcareous nodules. Near the village of Campigliano is a good section, where some of the upper beds are of a slightly reddish colour; but, in general, they have the dull grey appearance of an earthy alberese, sometimes assuming a concretionary character. The upper beds contain *Limnæa* and *Planorbis*. This formation extends to Colle, forming a flat, level plain covered with barely a foot of soil.

It would require a longer examination than I was enabled to bestow on it, to ascertain the exact age of this formation; from its position it seems to form an intermediate link between the arenaceous deposits of the marine beds already described, and the post-tertiary beds to which I am about to allude, being connected with the former by the arenaceous beds containing concretionary calcareous nodules, and with the latter by its immediate juxtaposition in the vicinity of Colle. On the other hand, both in its mineralogical character, and in the appearance of its fossils, it closely resembles the freshwater limestone of Cetona, which is supposed to underlie the blue marl formation.

3. POST-TERTIARY FORMATIONS.

The principal rocks which come under this denomination, are the deposits of calcareous tuff, assuming a concretionary and at times a spongy and tubular appearance, extending for several miles on both sides of the valleys of the Staggia and the Elsa. This formation has been alluded to by Mr. Lyell.* It is best developed in the valley of the Staggia. Near the town of that name is a horizontal formation of travertine, filling up the valley between the two ranges of sand hills, and forming a narrow lacustrine plain, through which the river has subsequently washed itself a bed, exposing the horizontal layers of tuff in the bed of the river. The extent of this deposit, probably derived from one spring or source, is very considerable, and may be traced from the town of Staggia to within a mile of Poggibonzi, a distance of nearly seven or eight miles. It is, however, so modern, that the shells found in it appear to be quite recent, and the stems of plants and roots, round which the calcareous tuff has been deposited, still retain, however slightly rotten, their wooden fibre. Impressions of leaves are very abundant in it.

The beds are more than 100 feet thick in some places; they are both calcareous and arenaceous, sometimes mixed. The variety of form resembles what Mr. Lyell has said † respecting the travertine deposited from the spring near the baths of San Vignone, and is probably owing to a similar cause. At times the calcareous particles are collected in concretionary and botryoïdal masses, sometimes almost stalactitic. Occasionally the beds are soft and friable, while others acquire the hardness and compactness of Scaglia limestone. Some of them are slightly ferruginous, and sometimes they present a strange conglomeration of cylindrical tubes. In places they are much contorted; in others, horizontal or slightly undulating. Species of *Paludina* and *Valvata* abound in some of the softer and more friable beds. This singular formation must have been deposited by a stream highly charged with calcareous matter, which, at no very distant geological period, flowed down the valley of the Staggia. A similar formation occurs in the adjacent valley of the

* Principles of Geol. vol. i., p. 398., 6th ed.

† Ib. p. 400.

Elsa near Colle. Other formations, referable to this same recent epoch, are the extensive alluvial and the now drained lacustrine deposits of the Val d'Arno, particularly that portion known as the Val d'Arno di sopra, extending from the rocky defiles of Incisa, once evidently the barrier of these inland lakes, through S. Giovanni, Montevarchi, and Levane, to Arezzo. This formation consists chiefly of denuded hills of gravel, sand, and yellow marl, resting against the secondary sandstones, and in which have been found the abundant fossil remains, chiefly of mammalia, which now form the riches of the museums of Montevarchi and of Arezzo. They include two varieties of Elephant, two species of *Mastodon*, remains of *Rhinoceros*, *Hippopotamus*, *Felis*, *Cervus*, *Bos*, *Antelope*, *Equus*, *Ursus*, and also some long plates of a Tortoise. They are so abundant in places, that the peasants have used them to mark the boundaries of their property, or to line the banks of the streams. The tusks of the elephant are enormous; the fragment of one at Montevarchi is 12 feet long, and nearly 2 feet in circumference.

Another recent deposit remains to be described in the neighbourhood of Chianciano. This place is famous for its hot baths, which are visited by strangers from all parts of Italy; near the source of the thermal spring is a curious natural basin of travertine, about 8 or 10 feet deep, and of an oblong shape. The natives believe it to have been excavated in the travertine, and then crusted over; but it is clearly the result of a natural deposit, formed by some abundantly calcareous spring, which has successively raised the walls of the basin or reservoir in which it rose. It has thus formed a perfectly level bank all round, on which circular lines or ripple marks are distinctly visible, showing the process of the formation. An irregular mass of the same matter extends some way down the hill where the water escaped, deposited by the overflowing of the pool: it is rather remarkable that no deposit whatever is left by the present hot spring, in which the thermometer rises to 31° Reaumur.

B. METAMORPHIC ROCKS.

I now proceed to describe the metamorphic rocks which came under my notice in those portions of Tuscany which I visited.

The only rock of this character is that called *gabbro rosso* by Savi. The origin and nature of this rock has been a matter of great uncertainty and dispute amongst geologists, both as to the period to which it belongs, and as to the source from whence it has been derived. It is here almost invariably of a reddish-brown colour, and is found in immediate contact with the serpentine or ophiolitic rocks, which abound in some districts.

The definition of this rock given by Savi in his memoir on the physical constitution of Tuscany is so correct, that I cannot do better than give an English version of his statement:—

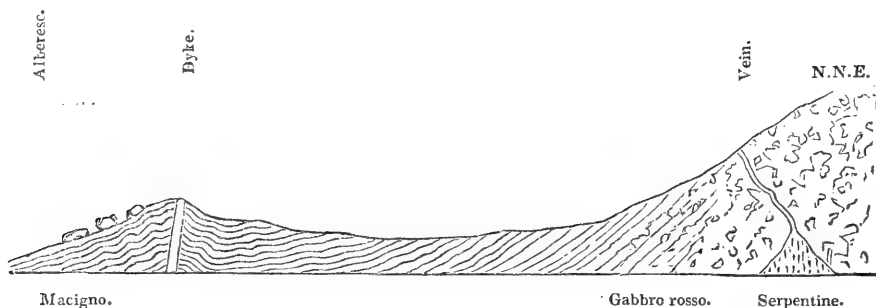
“We understand by *gabbro rosso*, or red gabbro, a class of “rocks produced by a particular alteration of the soil of the *macigno*,

“and particularly of its strata of schistose clay and limestone; an alteration caused by the ophiolitic rocks, and consisting not only in the induration and liver-red colouring of the strata, and in their contortions, but often in a perfect fusion or amalgamation of the neptunian with the plutonic rocks; by these means, many rocks of an ambiguous and varied appearance were produced, in which, at one time, the elements of the neptunian rocks pre-dominate, and at others, those of the plutonic, so that in former times they were said to belong to the transition formations. We have adopted for this class of products the generic name of *gabbro rosso*, being that which is usually given to it in Tuscany.”

The principal points where this rock is exposed are the copper mines of Monte Catini, and the mountain range extending thence to Castellina, besides a few spots on the south side of the Cecina, such as Libbiano, Monte Castelli, and, I believe, Rocca Sillana. The works at La Cava, the spot where the mining operations of Monte Catini are carried on, are all built on it, and very interesting sections are developed round the western extremity of this chain of hills. This rock has all the characters of being of igneous origin; but from careful examination there can be no doubt that it is an altered rock. The principal condition of its appearance is that of large irregular spherical masses, consisting of a darkish red argillo-siliceous substance, at first very hard, but becoming brittle and friable after a short exposure to the air. It is traversed by numerous small veins and filaments of calcareous spar, which facilitates its breaking in various directions. In some of these veins has been discovered a peculiar mineral which has received the name of *Caporcianite*, from the Chapel of La Madonna di Caporciano in the immediate neighbourhood. The centre of the veins of calc spar is sometimes more opaque and of a slightly redder hue; this has been analysed and found to contain a small proportion of manganese. It is said to be peculiar to these mines, and thence it has derived its name, these mines being under the peculiar care of La Madonna di Caporciano. The outer crust of these spherical masses shows after short exposure to the air a small mammillary appearance, which becomes larger as the exposure continues. It is evidently the result of decomposition, acting upon the surface of a body hardened under circumstances which produced a tendency to spherical or concretionary form, a tendency proved not only by this peculiarity of the surface, but by the fact of the whole of the rock consisting of these spherical masses; for not only does this condition appear in sections and surfaces where the rock has been long exposed, but it also occurs in fresh sections opened in the very heart of the mountain, many hundred fathoms below the surface, where the nodules or spheroidal masses, called *nuoccioli* by the workmen, and averaging 2 or 3 feet in diameter, are distinctly visible in the sides of the recently opened galleries. The intervening substance is generally very soft, and consists of green, red, and white earths, the red being generally in contact with the round masses, and the green and white more in the interior.

Although this is the general character of the rock, it frequently assumes other appearances. It is either compact and silicious, or it is argillaceous and soft; it has sometimes the appearance of hornstone or of quartz-rock, and it is at times altered into a mass resembling porphyry. This porphyritic appearance is well seen in the ravine behind the workshops of La Cava, where a portion of it has assumed a quartzose or hornstone character — if indeed this is not the result of veins of serpentine penetrating the metamorphic rock.

Notwithstanding various opinions which have been advanced, I have no doubt that the spheroidal forms assumed by this rock are the result of the conditions under which the cooling and induration of the mass took place, after it had been reduced by plutonic agency to a fused and liquid state. It bears an analogy to the formation of basaltic columns, indicating certain isolated points in which the cooling process, accompanied by certain principles of aggregation, commenced, extending its influence in all directions until interrupted by similar efforts proceeding from other points.



I have said above that this red gabbro is an altered rock; let us consider from what parent rock it has been derived. In the ravine to the south of the workshops and the mine of La Cava, is a good section of the gabbro rosso and true superincumbent beds, showing a gradual passage from the spheroidal masses into thin stratified highly contorted beds, dipping off at an angle of 50° or 60° to the south as represented in the above diagram. These beds are of the same dark liver-red colour, and break into similar small brittle masses, which at first cannot be distinguished from broken hand specimens. As we recede from the central mass of gabbro, the difference becomes more perceptible. Some of the beds are harder than others; and, on obtaining a real fracture, exhibit the appearance of a quartzose grit. Others are friable and gritty, and easily crumble to pieces, with the appearance of a half-baked brick. By degrees ascending the series, a few patches of grey colour occur in them, and this gradually increases. They are twisted and contorted in a most extraordinary manner, being turned completely over in some places like the mica schists and indurated marls of the primary and palæozoic formations, indicating the violence of the actions by which they were upheaved. As we get further from this sup-

posed igneous influence, the beds lose their former character; the shales become more marly and laminated, and the harder beds have a less cherty appearance. It is remarkable, considering the intensity of the agent which must have caused the change, to what a short distance it seems to have extended; for on descending the ravine, about 100 yards further, I came upon the secondary indurated marls, perfectly unaltered, of a grey white colour, resembling those near the Certosa at Florence and at Castiglion Fiorentino on the road to Cortona; and a little way further, the *alberese* or scaglia limestone is also seen unaltered, but dipping considerably to the S. S. W. Here then we have a key to the whole metamorphic formation, which is derived from the altered marls and sandstones (macigno) of the secondary or Apennine formation, acted on by the protrusion of the igneous rocks of the ophiolitic or serpentine class, which are found in the immediate neighbourhood. The passage of the red gabbro into the half altered beds of stratified sandstone and marl, I subsequently found in several other localities round this central mass, particularly on the road from La Cava to Monte Catini, where the contortions of the strata are well exposed, and are really deserving of notice from their extraordinary convolutions. Here, too, in a direct line from the summit of the Poggio alla Croce to Monte Catini, a gradual passage may be traced to the unaltered shales, limestone, and macigno.

C. IGNEOUS ROCKS.

These appear to me to belong to three distinct periods :

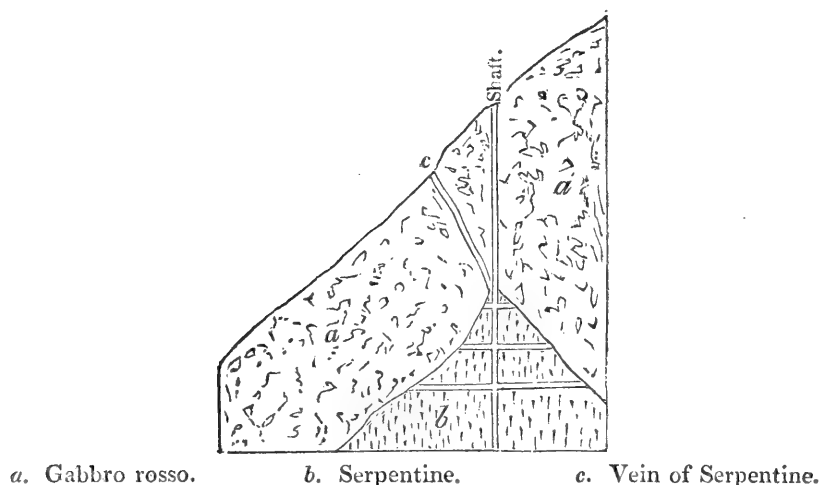
1. Serpentine, or ophiolitic rocks (Trap of secondary period).
2. Selagite of Monte Catini (Trachyte of tertiary period).
3. Basalt of Radicofani (Recent).

1. *Serpentine.*

This rock is developed in many parts of the western portion of the Tuscan States. The principal localities where I had an opportunity of observing it, are at the copper mines of La Cava, and along the chain of hills extending from Monte Catini to Castellina, including Monte Miemo. To the south of the Cecina, it bursts forth at Monte Libbiano, where it rises to a considerable height — at Monte Rufoli, where it covers an extent of many miles — at Monte Cerboli — Rocca Sillana and Monte Castelli — all belonging to the same system. Near Florence it also shows itself in two spots, L'Impruneta and Prato, the latter of which I did not visit. It varies considerably in its appearance, character, and hardness, its chief permanent characteristics being its green colour and its soapy feel.

At Monte Catini the rock is soft and soapy, occasionally containing portions of a harder nature. It is of a uniform greyish-green colour, without the white spots which give to that of Prato, L'Impruneta, and Monte Rufoli its peculiar character, resembling the serpentine of antiquity. It here derives its principal interest from the copper mines with which it is associated. The copper ore, which is exceedingly rich, occurs in irregular veins and

nodules, following the line of junction between the serpentine and the gabbro rosso. Not that any distinct formation exists between these two rocks; but the copper ore itself generally lies between them; sometimes extending itself into the gabbro, and more frequently into the serpentine, in which it forms large deposits, near the junction of the two rocks.



When this mine was opened, a narrow vein of soft talcose serpentine appeared on the surface, penetrating the gabbro rosso. (See diagram.) This was followed down in a N. E. direction in search of copper; and at the depth of 66 metres, the miners found what appeared to be another vein rising up from the opposite side, and forming a *conjunction*, as they call it; and at this spot a very rich deposit of ore was discovered. The main shaft has been sunk so as to strike on this spot, which is, as it were, the apex of a dome of serpentine, over which metallic deposits are found in all directions, following the line of junction between the serpentine and the overlying gabbro rosso. *Below* this junction point, the shaft, to the depth of some hundred feet, passes through solid serpentine only; which, although soft at first, becomes so hard as to require to be blasted with powder. The ore is a sulphuret (?). The richest portions, which are of a blue-iron colour, produce from 60 to 65 per cent., the poorest about 25 to 30 per cent. The ore is generally in the form of irregular nodular masses, here called ore stones, varying in size from a man's hand to masses several feet in diameter. Sometimes it occurs in large deposits several feet in length and height, and at others it forms a continuous band of a regular thickness, extending some distance along the line of junction of the two rocks. Large masses have also occasionally been met with in the cross galleries, at a distance of 25 feet from the red gabbro; and, on one or two occasions, nodular masses have even been found in the gabbro rosso itself close to the serpentine, which must be considered as the principal

agent in the formation of the ore. The amount raised in the year ending September, 1843, was 1,894,765 Tuscan pounds.

In the vicinity of the junction of the serpentine and gabbro, a rather remarkable substance is occasionally found, called Losima. It is generally of a bright red colour, extremely shining and brilliant, soft and soapy to the touch, and apparently argillaceous. It is perhaps the result of friction. In carrying a gallery to the N.E., for the purpose of communicating with a new shaft, the miners have traversed another mass of serpentine; but very slight indications of ore have as yet been perceived in it. The strike of these masses of serpentine, or dykes as they may perhaps be called, is from N.W. to S.E., which coincides with the direction of another serpentine dyke which I traced some way over the hills to the S.W. of La Cava. It may be observed, too, that their direction is parallel to that of the principal mountain chain in this part of Italy.

Veins of steatite (or soap-stone, Pagoda stone, *pietra di sarto*, as it is here called), which sometimes assumes a very asbestos form, occur frequently in the serpentine; and this is a considerable object of export commerce. One of the localities where this steatite is found, is remarkable from the occurrence of numerous veins or layers of carbonate of lime, perhaps deposited by calcareous springs rising up through the serpentine, or it may be the result of chemical segregation, by which the steatitic particles were separated from the lime, and formed into distinct nodules. Perhaps the different appearances would justify both suppositions.

At Monte Rufoli, the serpentine extends over a considerable tract of country, covered with magnificent forests of ilex, which render its examination almost impossible. Here, however, the rock is remarkable for being the seat of the quarries of chalcedony, which supply the beautiful agates used in the Royal and other manufactures of *pietra dura* at Florence.

About two miles east of Monte Rufoli, and on the slope of the hills facing the valley of the Sterza, are the chalcedony quarries. At first their appearance resembles that of quartz dykes, rising up through the serpentine, and forming a low wall, a few feet above the ground. Wherever they have been worked, however, they appear to cease about eight or ten feet below the surface, thus leaving a kind of ditch on the hill side, about three or four feet wide, and varying in depth from eight to ten feet. Besides these principal dykes or masses, of which there are said to be several, although I only saw two, the serpentine is traversed in various directions by small, irregular veins of chalcedony, generally of a reddish colour: other similar masses of siliceous substances overlie the serpentine, as if spread over the surface from the larger dykes, differing both in character and appearance, and representing every possible variety of chalcedonic and agate bodies. They contain numerous cavities, the inner coats of which are covered with botryoïdal and mammillary chalcedony; also masses of concretionary, whitish-grey, earthy chalcedony, with a gradual shading from

light to dark yellow near the edges. These are the parts most sought after by the lapidaries of Florence, on account of their beautiful shadings, and the effect they produce in the "pietra dura" works: other portions are more transparent, consisting of agates, cornelians, and opalines of various colours.

These silicious masses, as I observed, are situated in the soft, decomposing serpentine, in which, on each side of the principal dyke, are several thin, narrow filaments of silicious matter (chalcedony), generally of a reddish colour, and parallel to the principal mass.

With regard to the origin of this curious variety of chalcedonic formation, my first impression was, that it must have been a quartz dyke, rising up through the serpentine; but the variety of colour and character which the rock exhibits, incline me rather to attribute it to an aqueous origin. It might be considered as the result of a thermal spring, charged with silicious matter which has been deposited in fissures of the serpentine, unless the occurrence of the remarkable *soffioni* or vapours of Monte Cerboli, in such close vicinity, and that of other similar phænomena in the same district, render it more probable that it is owing to the escape of vapours charged with silicious and other matters; when the silix, as the least soluble, would be first deposited on any sensible diminution of temperature. The subject is one of considerable interest, as connected with other geological phænomena in the country.

Between the village of Monte Gemoli and the high and lofty position of Libbiano, the river Trossa has forced its way through a narrow pass between two masses of serpentine of the same character as that of Monte Rufoli. At Libbiano itself, the serpentine and greenstone rocks have been elevated to a considerable height, carrying with them to the summit a conglomerate of the pre-existing rocks, gabbro rosso and Apennine limestone, mingled with masses of serpentine; these cover the north-east flank of the hill, and give a remarkable appearance to the elevated narrow ridge on which this desolate village has been perched.

Another interesting locality where the serpentine occurs is near the village of L'Impruneta, about six miles south of Florence. The village stands on a hill of green serpentine which crops out even in the market-place, though the principal mass of it is about half a mile further south. It rises up through the secondary rocks, which dip off from it on all sides, more or less altered, and in some places reduced to the metamorphic state of red gabbro, in which all traces of stratification are obliterated.

A new road has been cut through the solid serpentine, leaving a cliff fifty or sixty feet high on each side. Here the rock appears darker and blacker than on the surface, but equally susceptible of decomposition on exposure to the air. Besides the numerous crystals of a pale green colour, which distinguish the serpentine of L'Impruneta, many portions are traversed by thin veins of calcareous spar; others are beautifully marked with red veins, and

are much sought after by the statuaries of Florence for ornamental works; others contain veins and masses of a fibrous substance, which sometimes closely resembles the fibrous asbestos; the latter becomes harder by exposure, exactly the reverse of the serpentine itself. Near the south end the serpentine assumes a more scoriaceous character: here the asbestos is more abundant, and in some places penetrates the serpentine with many branching veins; the people called it "*pietra alberisata*," from its resemblance to the fibres of a tree fossilized.

On the south-east side, near the junction of the serpentine with the stratified rocks, altered into red earthy jasper, and either perpendicular, or inclined at an angle of 80° , with a north and south strike, the igneous rock is much decomposed and softened. It is traversed in every direction by numerous veins of carbonate of lime, which, not decomposing so rapidly as the rock itself, stand some inches above the ground, presenting a curious reticulated appearance.

I did not visit the other spot in the vicinity of Florence in the mountains above Prato, ten miles north-west, where the serpentine is also quarried, and is worked up in Florence for ornaments under the name of *Verde di Prato*.

2. *Selagite of Monte Catini.*

This name of Selagite is given to a quasi-trachitic rock, the only instance I observed of such formations, rising up through the blue marls at the western extremity of the chain of hills on which is situated La Cava and its copper-mines, and on the upper portion of which stands the ancient village, or Borgo of Monte Catini. Its sides present an almost perpendicular face, in which the columnar structure is very visible, but the columns, though of considerable length, are irregular both in size and form. It is of a bluish-grey colour, gritty to the touch, and full of small crystallized plates of hornblende or amphibole. It is considerably quarried for building-stones, much used in the neighbourhood. Although apparently unconnected with the serpentine rocks, it is remarkable that this trachitic outburst has taken place almost on the direct axis or line of prolongation of the strike of the serpentine masses, which appear to have caused the elevation of Monte Massi and Poggio alla Croce. From the altered appearance of the shelly bed, already described on its north flank, its protrusion probably took place during the early part of the tertiary period.

3. *Basalt of Radicofani.*

The other igneous rocks to be noticed are the basalts of Radicofani, of which, however, I only introduce the name here, to complete the series, as I had no opportunity of visiting them.

I cannot conclude this imperfect notice of the geology of Tuscany without calling attention to the boracic acid works at Monte

Cerboli, and the remarkable phænomena therewith connected; for I have no doubt but that many of the actual geological features of Tuscany must be referred to agencies and to causes similar to those which are now exhibited in this locality. The works have been already in some degree described by Mr. Babbage in *Murray's Handbook of Central Italy*, p. 178., and by Dr. Bowring in his Report on the Commercial Relations of Tuscany, laid before Parliament in 1837. I shall therefore confine my observations to a few of the principal phænomena.

The numerous and violent jets of vapour from which the boracic acid is extracted, rise, with considerable noise and in large volumes, from a narrow rocky valley in the secondary cretaceous limestone, about 15 miles S. W. of Volterra. Huge blocks of this rock and its associated indurated marls cover the surrounding hills, and add to the desolation of the scene. The vapour naturally leaves a considerable deposit; but this is much increased in consequence of its being compelled by artificial means to pass through water collected into numerous reservoirs. By this process, the water is impregnated with the boracic acid previously held in solution in the vapour; while the greater part of the sulphur, lime, and carbonic acid gas, which it also contains, is deposited in the muddy bottoms of the pools, and assumes, when dry, a crystalline form, being, from time to time, thrown out in the course of the operations: sulphate and carbonate of lime are also deposited in the cauldrons and cooling pans where the boracic acid is obtained by evaporation from the saturated water. Amongst the neighbouring rocks, I saw a remarkable instance, where a large fissure or crack, with several smaller ramifications, had been completely filled up by the matter deposited by the vapour which must once have escaped through it. The sides were coated with a hard compact calc-sinter, while the central portions were filled with a more porous substance, so that the passage of the vapour had been obstructed before the central parts had become so densely consolidated as the sides, thereby explaining at least one of the causes by which these vents are constantly changing their positions, and how the jets of vapour escape sometimes in one place and sometimes in another.

The simple mode by which the boracic acid is obtained is as follows. Small reservoirs, from 15 to 30 feet in diameter, are dug round the most convenient and powerful of the many steam vents; and into these reservoirs a small stream of water is conducted from the mountain side. After being for some time exposed to the action of the rising vapour the water is let off from one reservoir into another, until it has passed through five or six, in each of which it remains about 24 hours, the vapour boiling and bubbling up through it the whole time with much noise and violence. By this time the water is sufficiently impregnated with the boracic acid; and after being allowed to settle in another reservoir to deposit the mud, it is led off into the evaporating houses, where, after undergoing a slow and gradual process of

evaporation, the boracic acid is at length obtained in numerous vats, where it crystallises with great facility.

The great difficulty formerly experienced in this process was the expense of fuel required for the process of evaporation; until the happy idea at length suggested itself to the proprietor of availing himself of the almost inexhaustible supply of heat prepared by Nature herself in the numerous vents from which the streams of boiling vapours were constantly emitted. Acting on this suggestion, he built a sort of chamber over some of the vents, and conducting the vapour by subterranean channels into the evaporating houses, obtained without a farthing of additional outlay all the heat he could require. The consequence of this simple application of natural power was, that the value of the works rose, in one year, from a capital of one thousand pounds, for which the fee simple was offered, to a rental of twenty thousand pounds per annum.

Similar vapours or "soffioni," as they are called, occur in several other localities in the same district, or within a distance of 12 or 14 miles, as at Sarrezano, Castel Nuovo, Monte Rotondo, and others; and it is impossible not to be struck with the manner in which they throw light on many of the geological phenomena in this and other countries; particularly with regard to the filling up of cracks and fissures in rocks, and the local deposits of various substances, such as calc spar, gypsum, sulphate of lime, sulphate of soda, &c., many of which occur in this very neighbourhood. It is highly probable that such emissions of gases and vapours may have produced many of those local phenomena, which have been so frequently attributed to the effect of springs, and are considered as aqueous deposits. That great connection exists between them cannot be doubted, as the soffioni of Monte Cerboli do unquestionably deposit much sulphate and carbonate of lime, and if supposed to rise through water would most certainly deposit much more. On the whole, therefore, whether we consider the remarkable and almost terrific appearance of these vents, from hundreds of which the vapours escape with the noise of a steam-boiler blowing off its steam, or the importance they have in connection with other geological problems to which they may offer a solution, they must be considered as presenting to us some of the most interesting, if not important geological phenomena which the Tuscan States can afford to the pursuer of geological investigations.

NOVEMBER 20, 1844.

Charles Faulkener, Esq., and John Bravender, Esq. of Cirencester, were elected Fellows of this Society.

The following communication was read :—

On the GEOLOGY of GIBRALTAR. By JAMES SMITH, Esq. of Jordan Hill, F.G.S.

IN the absence of the author of this paper from England it has been considered advisable not to publish more at present than a mere announcement of the nature of the conclusions arrived at. After stating briefly the appearance and character of the fundamental rock at Gibraltar (which is of the oolitic period), the author mentions indications of recent marine action, extending up to the very summit of the mountain, and proceeds to describe his reason for concluding that great and repeated elevations have taken place in the district in comparatively modern periods, three being more especially remarkable, since each one of these has elevated the strata through an angle of about 20° . Several interesting phenomena of the tertiary period are alluded to as affording evidence in favour of this view. The author concludes by directing attention to some superficial deposits of sand, covering the flanks of the mountain, and to the bone breccia, some parts of which he considers to be of great age.

DECEMBER 4, 1844.

Henry Coles, Esq., of Cheltenham, Dr. Travers Cox, Professor Edward Forbes, and I. K. Brunel, Esq., were elected Fellows of this Society.

The following communications were read :—

1. *Remarks on the GEOLOGY of BRITISH GUIANA.* By SIR ROBERT SCHOMBURGK, Ph. D. &c.

THE district alluded to by the author in this paper extends along the shore of the Atlantic from the mouth of the Amazons river to the embouchure of the Orinoco, its greatest length (between Cape North and the confluence of the Rio Xie with the Rio Negro) being about 1090 geographical miles, and its breadth (from the mouth of the Orinoco to the confluence of the Rio Negro with the Amazons) 710 miles. Throughout this tract no organic remains have yet been discovered, the whole being occupied by primitive rocks.

The banks and low lands near the chief rivers of Guiana are described as consisting at the surface of a bluish clay, impregnated with salt and mixed with decayed vegetable matter, forming a very productive soil. The delta of the Orinoco, and the embouchure of the Essequibo, present the same appearance.

The blue clay just described is usually succeeded by other clays of variegated colour, and these again by sands, composed of transparent white quartz. Water has been frequently obtained by

boring through the clay to these sands, and in such cases the depth from the surface to which it has been necessary to sink varies from 120 to 230 feet.*

The clay extends for a considerable distance inland, and is then terminated by a range of sand hills from 30 to 120 feet high, parallel to which may be traced a number of detached groups of hillocks, seldom more than 200 feet high, and consisting of red iron ochre with occasional layers of silicate of zinc. This is succeeded by a quartzose sandstone resembling the flexible sandstone of Brazil.

The first unstratified rocks occur near Itaka, and consist of different varieties of granite with numerous greenstone dykes, and of porphyry, while in the surrounding mountains, at no great distance, clay iron-stone was observed in small detached nodules. This rock is repeated again towards the south, and occupies the extensive plains or districts of table land, called "Savannahs," which are about 300 feet above the sea, and from the midst of which rise isolated hilly groups from 1800 to 2300 feet above that level. These plains are covered by a conglomerate, containing rounded fragments of quartz, and vast quantities of bog iron ore, while blocks of granite, some of them of large size and much rounded, also abound. The hills are porphyritic, and exhibit also a considerable quantity of mica in foliated masses.

A sandstone resting upon the small-grained gneiss and coarse granite of the Savannahs is next described by the author as forming the mountains of Pacaraima which extend from the upper Orinoko, eastward, to the banks of the river Essequibo. Towards the north, felspar-porphyry, and jasper, are also mentioned, and then succeed lofty escarpments of sandstone rising almost perpendicularly from the plain, and forming the commencement of an extensive range of high table land. This sandstone is described as entirely destitute of organic remains.

Having alluded to these rocks, the author next describes some of the appearances presented by the clay, and other materials in the bed of the river Cukenam, near which on both sides rise lofty mountains, on whose declivities nodules and large blocks of pisiform bog iron ore are found. After this follows an account of another region on the right or western bank of the Cukenam, in which jasper is so abundant as to form the prevailing rock. The mountains are described as rising in a highly picturesque and striking manner to the north of this locality, and are said to be composed of compact sandstone, whence it appears that this rock occupies the highest summits from the banks of the Orinoco towards the south-west, and a similar ridge has also been traced by the author considerably to the west and south. Large blocks of granite are also mentioned by the author as abounding on the flanks of the highest mountains, one of which "Roraima" is espe-

* Ten or twelve feet below the upper surface an irregular stratum of fallen trees (*Avicennia nitida* of botanists) is met with, and a similar bed, 12 feet thick, has also been found at a depth of 50 feet.

cially alluded to as exhibiting much grandeur and great picturesque beauty. Northward of this mountain clay slate is described as being present, and near it, by the banks of the Carimani, black quartz, while in the basin of the river Cuyuni large blocks of coarse conglomerate were seen, although near the junction of that river with the Mazaruni the rocks were basaltic. The rocks at the great falls of Ematupa are said to consist of granite and dark indurated clay slate.

The author next directs attention to various rocks of grotesque form, found in the granitic district of Guiana; some of these, called the 'pyramids,' being of granite and other porphyritic rock, and forming very striking objects in the landscape.

In conclusion, the author states that the geological features of Guiana in some districts render it most probable that gold is present, and that he found specimens in the river sand of the Takutu, which, judging from the tests he was able to employ, he had no doubt were fragments of this precious metal. These specimens, however, with many others, were lost in the course of his journey; but Fray José, the catholic missionary, showed him a piece of massive gold partly embedded in quartz, which had been found on the banks of the Rio Branco where the Takutu enters that river.

The presence of Itakolumite, of mica slate, and of what in Brazil is called the Diamond matrix, proves the existence of a structure in the Savannah regions of Guiana similar to that of the Serra do Espinhaco in the province of Minas Geraes in Brazil.

2. *A Letter to DR. BUCKLAND on the subject of GLACIER MARKS in SOUTH WALES.* By W. C. TREVELYAN, Esq.

THE object of this letter was to direct attention to certain polished and scratched surfaces in the valley of the Conway on the ascent of Moel Siabod and in other places near Snowdon. The author considered that these and other markings he had observed were indications of the former presence of glaciers in these localities.

DECEMBER 18, 1844.

The following gentlemen were elected Fellows of this Society: — Robert Chambers, Esq., of Edinburgh; James Simpson, Esq., of Chelsea; William Lewellyn, Esq. of Pont-y-Pool; and James Bandinel, Esq. of Westminster.

The following communication was read: —

On the PIPES or SAND-GALLS in the Chalk and Chalk-rubble of NORFOLK. By JOSHUA TRIMMER, Esq., F. G. S.

IN a paper read before the Society in the Session of 1842-3, and

intituled "On Pipes or Sand-galls in Chalk*," I have shown that, in the county of Kent, these cavities in the chalk have, in their upper part, a longitudinal extension, and are connected with furrows which traverse the upper surface of the chalk, and which widen and deepen as they approach the pipes. From the nature of the materials with which these cavities are filled, I inferred that, in that county, they were formed before the deposit of the oldest Eocene strata. From the fact, also noticed by me in the same county, that similar furrows and pipes, though of smaller dimensions, occur in the blocks of siliceous sandstone which are dispersed through the superficial deposits, and are derived from the sands of the plastic clay, I concluded that these cavities were caused, not so much by the chemical as by the mechanical action of water; and, from the further observations I made, that still smaller furrows and pipes are actually in the course of formation on the surface of similar siliceous blocks on the coast of Kent, I judged that the mode of this mechanical action was by the flux and reflux of waves breaking on the shore.

Having now extended my observations to the chalk in the vicinity of Norwich, I find that in that district also the pipes constitute the termination of longitudinal furrows; and in this paper I shall adduce evidence, from the phenomena observable in the superincumbent strata of sand and gravel, that these hollows were excavated in the chalk just before the deposit of the Norwich Crag, and that, like the pipes in the chalk of Kent, they owe their origin to the mechanical action of water.

I will first offer some general remarks on the chalk, and on the strata overlying the chalk, in the vicinity of Norwich.

The chalk which bounds the continuous valley watered by the rivers Wensum and Yare, rises to the height of from 60 to 80 feet above the river level. It is covered by the sands and gravel belonging to the Norwich Crag and the Northern Drift. These form a nearly level plateau, intersected by many inosculating valleys, some containing streams, others dry. To judge from the sections laid open around Norwich, the greatest thickness of the supra-cretaceous deposits, at the highest points of this plateau, is about 60 feet: towards the valleys these deposits thin off.

Immediately upon the chalk rests a ferruginous breccia, locally termed "the pan," from one to two feet thick, and composed of large unabraded or slightly water-worn flints; and these are sometimes mixed with marine shells, unbroken and in fragments. It is in this, the most constant member of the crag series in this part of Norfolk, that the bones of terrestrial mammalia are found.†

Above the breccia are beds of sand and silt, containing, in some places, considerable accumulations of unbroken marine shells. These accumulations sometimes occur in drifted masses from one to four feet thick; sometimes they consist of groups of two or three

* Vide "Proceedings," vol. iv. p. 6.

† Mr. Wigham, who has been in the habit of purchasing bones of the workmen for many years, informs me that each pit yields about one bone a year.

species of shells, imbedded in silt, the bivalves having their two valves united, and lying evidently on the spot where the inhabitants of the shells lived. Both of these modes of association may occasionally be seen in the same pit; and they are very different from the arrangement of the shelly remains in the till and in the stratified drift. The greatest height from the surface of the chalk at which I have met with these shells, is less than ten feet.

The rest of the deposit consists of alternating beds and bands of gravel and laminated clay, which, in their upper part, where the stratification is less regular than in the lower, are occasionally associated with unstratified masses of yellow loam. The beds, particularly in their lower part, are often obliquely laminated; and in a cutting of the Yarmouth Railway, between Thorpe and Crostwick, the shelly beds of the crag, which are there seen in contact with a mass of unstratified blue till, exhibit contortions like those which occur in the Cromer Cliffs.

The epoch of the Norwich Crag was of considerable duration. On the coast of Norfolk, at Mundesley, we see the lowest member of that formation, the pan, overlaid by a fluviatile deposit; and at Runcton Gap* a similar fluviatile deposit is overlaid by a bed containing shells of the same species that belong to the pan of Mundesley and Happisburgh.

At Happisburgh the pan is overlaid by a bed of large fossil trees; and these are buried beneath stratified and unstratified drift. Near Norwich there is no trace of the intervening period when the crag became dry land. Moreover, the only instance I have seen of blue till in that neighbourhood, is in the cutting of the Yarmouth Railway above noticed; and in the general absence of this unstratified detritus, there is nothing in the district to define the limits between the crag and the stratified drift, which might pass together for one continuous deposit.

I will now proceed to describe, in the first instance, the appearances I observed in two pits worked in the solid undisturbed chalk, situate within five miles of Norwich. In these pits, twice or thrice a week for several months, I made measurements and drawings of the surface of the chalk and of the cavities in it, as, during the progress of the works, they became cleared of the overlying deposits.

In describing these and the other pits referred to in the present paper, I shall adopt the following local terms, used by the workmen. Cavities in the chalk, of greater breadth than depth, they call "drops"; deep conical or cylindrical pipes in the chalk, they call "pots"; the overlying gravel, sand, &c. they call "uncallow."

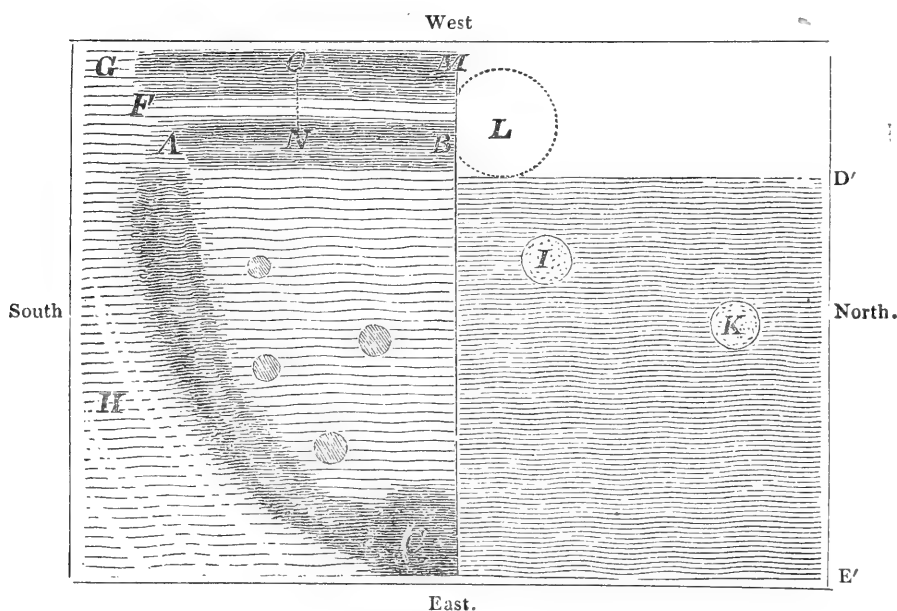
* The bed of shells at Runcton occurred to the east of the Gap; but on a visit I made to the spot in the spring of 1845, a fall of the cliff had covered up the bed. To the west of the Gap, however, I found a bed of marine shells, lying, like that to the east of it, above the freshwater deposit. The frozen state of the cliff prevented my obtaining specimens. The shells I found to the east of the Gap were, *Natica helicoides*, *Mya* (a large species), *Fusus striatus*? The shells I observed to the west of the Gap were all of the same species, viz. a large truncated gaping bivalve, and had both valves united.

The first of these two pits is situate in the village of Thorpe, about a mile to the east of Norwich, at the junction of the great east and west valley of the Yare with a small north and south valley. The works are prosecuted in the direction of both valleys.

Owing to the great thickness of the uncallow (from 15 to 70 feet), it is removed only to a small extent at a time; and when the chalk has been worked away to that extent, a fresh space is cleared for working.

Fig. 1. THORPE CHALK PIT.

(Ground Plan.*)



The diagram (fig. 1.) is a ground plan of so much of this pit as I propose to describe. On the left hand, outside of the curved line C A F G, the chalk had been worked away long before my first visit to the pit, and the outer space was filled with refuse from other parts of the works. At the surface of the chalk, over part of this space, to the left of a line drawn from H to F, there had occurred, as the workmen stated, a large "*drop*." When I first visited the pit, the chalk had been worked away in the excavation B C E D (of which a portion only is represented) to the depth, measured from the surface of the rock, of about 50 feet; and subsequently, in the course of the season, it was removed to a further depth of 5 or 6 feet, when the workings were interrupted by water.

C A B is a triangular surface of chalk, of which the length C B is about 18 feet, and the breadth at the further side A B, about 15 feet. On my first visit to the pit, it had been recently cleared of uncallow; and a clean vertical section, about 60 feet deep, of

* In this diagram certain furrows which ought to have been indicated, and which proceed towards the west and south-west, from near the round marks on the left-hand side of the middle of the diagram, have been accidentally omitted.

deposits of that description, then presented itself above the chalk, along the whole of the line A B D.

Subsequently, the uncallow was removed also from the space B A G M (about 15 feet by 9 feet); and afterwards, to the whole extent of that space, and of the triangular space C A B, the chalk was worked away, and a vertical section of the uncallow was then exposed above the lines G M and M B.

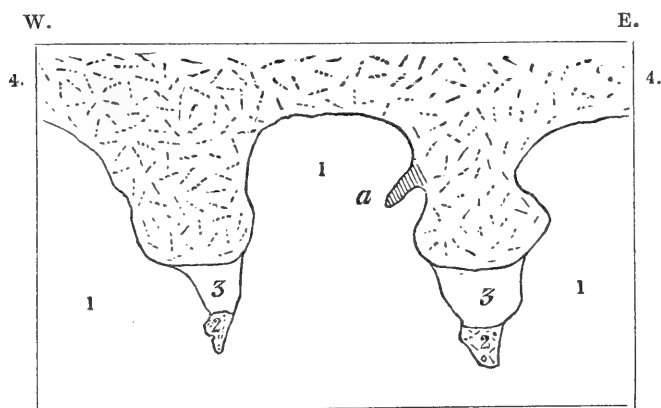
At C was a large conical pot. At I and K, in the floor of the excavation B C E D, were horizontal sections of two cylindrical pots, each about $2\frac{1}{2}$ feet in diameter; and, as the workmen stated, these pots had been of the same diameter throughout their whole lengths of 55 feet; and at that depth from the surface of the chalk there was no appearance of their terminating. Most of the pipes in this pit extended, as the workmen stated, to the very bottom; though occasionally a pipe, on its meeting with a layer of flints, would stop abruptly. At L was another large pot.

On the surface of the chalk, in the triangular space C A B, were several circular basins, about 10 inches in diameter, and 2 or 3 inches deep in the centre: there were also several very shallow irregular furrows.

On the outer margin of this space, extending from the pot C to A, were the remains of a deep curvilinear furrow; from A to B was a straight deep furrow, communicating at B with the pipe L; and parallel to A B was another deep furrow, extending from G to M.

Fig. 2. THORPE CHALK PIT.

(Cross Section of the two Furrows G M and A B, from O to N.)



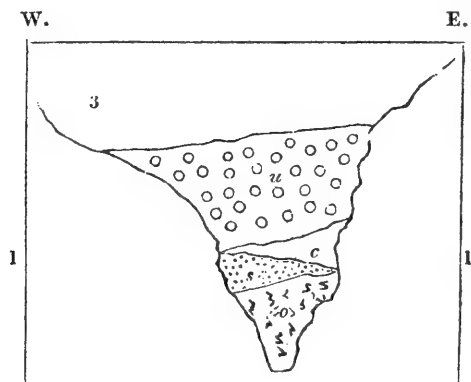
1. The solid chalk.
2. The bottom of the furrows G M and A B, filled with sand, umber, and yellow ochre, and sometimes containing thin layers of chalk.
3. Layer of reconstructed chalk.
4. Sand — (a.) represents a projection filled with umber.

A cross-section of these two furrows, on a line N O, nearly midway between the points A and B, is represented in fig. 2.; and fig. 4. is another transverse section of the same two furrows, drawn through the points A and G. On each of the above

lines of section, the furrows are excavated in solid chalk, and they are separated from one another by an intervening ridge of solid undisturbed chalk.

Fig. 3. THORPE CHALK PIT.

(Cross Section of the bottom of the furrow G M.)



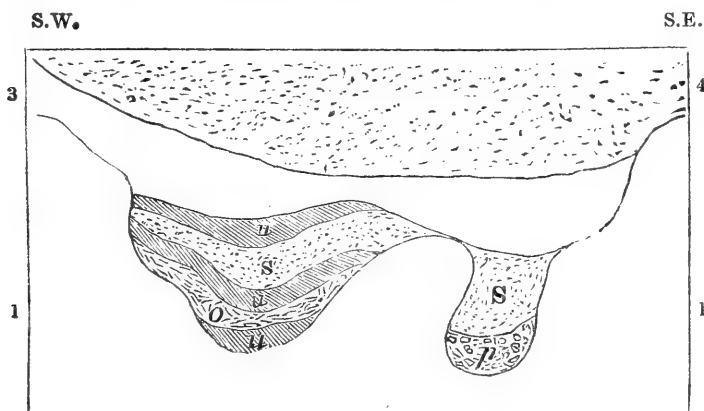
- 1. Solid chalk.
- o. Yellow ochre.
- s. Sand.
- c. Chalk.
- u. Sand mixed with umber.
- 3. Layer of reconstructed chalk.

On the line of section N O, each of the furrows is from 7 to 8 feet deep, and, at the surface of the solid chalk, is about 4 feet wide; but on the line of section A G, both the furrows are wider and shallower. At and near the line of section N O, the width of the furrows on a level with the surface of the solid chalk, is sometimes less than it is about a foot and a half below that level; but at a greater depth the width again diminishes, and it then tapers downwards to the bottom. Sometimes, however, the transverse section is nearly that of a wedge.

Near the line of section N O, the lower part of the furrow G M, to the height of about a foot from the bottom, was irregular in shape, and, at that height, was from $1\frac{1}{2}$ to 2 feet wide. This part was sometimes filled with a mixture of yellow ochre and umber, of a blackish or brown colour, and very low specific gravity: sometimes the umber lay above and the ochre below, a thin layer of fine sand separating the two; sometimes a layer of fine ferruginous sand lay beneath the ochre and umber, and sometimes, as in Fig. 3., thin irregular layers of chalk were mixed with the other contents of this lower part of the furrow. At the bottom of the furrow A B, near the point A in the ground plan, was an accumulation of water-worn pebbles, which was covered by sand. (See Fig. 4.)

Fig. 4. THORPE CHALK PIT.

(Cross Section of the two furrows G M and A B from G to A.)



- 1. Solid chalk.
- o. Yellow ochre.
- u. Umber.
- S. Sand.
- p. rounded pebbles.
- 3. reconstructed chalk.
- 4. Sand.

Near the line of section N O in each of the furrows, at the height of about a foot from the bottom, was a layer of chalk about 4 feet thick, but thicker towards the sides of the furrow than towards the middle. The chalk bore evident marks of reconstruction in some of its parts, but in other parts was apparently so solid as to render it difficult for the observer to believe that it had ever been disturbed. The upper surface of the reconstructed chalk in each of the two furrows appeared to have been exposed to the same kind of furrowing action which the solid chalk has undergone at the base of the furrows. From the top of this layer of reconstructed chalk to the level of the surface of solid chalk, upon this line of section, was a perpendicular height of 3 or 4 feet. This space in the furrow A B was filled with fine sand, intermixed frequently with much umber, less frequently with yellow ochre, and sometimes with a mixture of the two; and in one part, where the surface of the layer of reconstructed chalk was depressed below its ordinary level, a layer of rounded gravel occurred beneath the sand. Above the layer of reconstructed chalk, in the furrow A B, small conical protuberances, about 4 inches in length and diameter, projected from the sides of the furrow into the solid chalk, in which they formed cavities, and these cavities were filled with umber. (See fig. 2.)

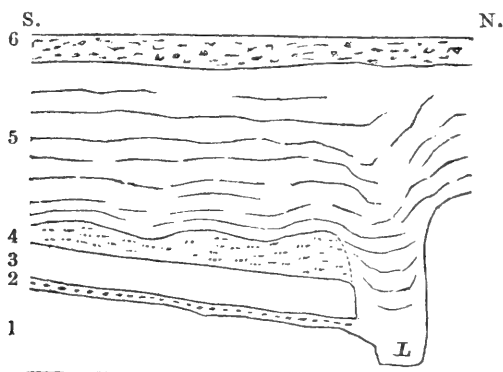
It is probably from the decomposition of the iron pyrites in the chalk, that the yellow ochre in these furrows has resulted; for it is often seen forming small lumps in the solid chalk, near the surface of

the latter. The umber is of frequent occurrence, in connection with the pipes in the chalk, both in Kent and Norfolk. In the former county I have found pipes 6 inches in diameter, and 2 feet in depth, nearly filled with this substance; and I have frequently observed it mixed with the clay which lies between the chalk and the overlying loam, and which also forms the lining to the pipes. In Norfolk it enters largely into the composition of the pan, and occurs as well in the pipes as in the furrows; but I have nowhere met with it so pure, nor in such large masses, as in the lower part of the furrow G M, above described.

The reconstructed chalk, which, in the line of section N O, lay within the furrows at the depth of 3 or 4 feet below the surface of the solid chalk, completely fills up and overtops the furrows and the ridge of solid chalk which divides them, on the line of section A G. Over this layer of reconstructed chalk, extending continuously from furrow to furrow, lies a bed of sand.

The following figure (5.) is a vertical section, passing north

Fig. 5. THORPE CHALK PIT.



1. The solid chalk.
2. The bottom of the furrow A B, filled with sand, umber, and yellow ochre, and occasionally containing thin layers of chalk.
3. Layer of re-constructed chalk.
4. Sand.
- S, S' General surface of the solid chalk, at the sides of the furrow.
5. Sand, alternating, in the lower part, with seams of clay and gravel. From S, S' to the top of 5, the height is about five yards.
6. Loam, sand, and gravel. From the bottom of 6 to the surface is about eighteen yards.
- L. The sand-pipe, so marked in the ground-plan, fig. 1.

and south along the middle of the furrow AB. It shows the connection of that furrow with the pipe L, and the manner in which the lower strata of crag bend down into the broader and deeper pipes, such as L appears to be. Since the disturbance of the strata does not extend more than 15 feet above the general level of the surface of the solid chalk, the upper horizontal strata of loam, sand, and gravel, of the aggregate thickness of about

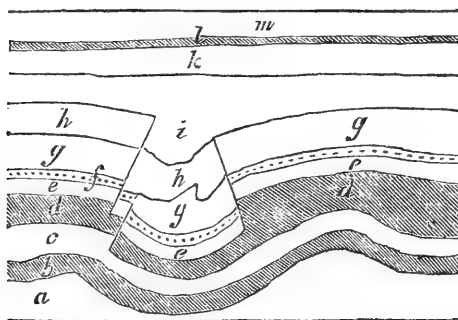
18 yards, which lie above the disturbed strata, are omitted in the figure.

The strata overlying the chalk, as exhibited in vertical section over the line G M in the ground plan, were the following, in descending order :—

			Feet	In.	Feet	In.
	Loam, with patches of gravel	-	-	30	0	
m.	Sand, with seams of gravel	-	-	21	0	
					51	0
			Feet	In.		
l.	Clay	-	-	0	6	
k.	Sand	-	-	2	0	
i.	Dark brown gravel, about	-	-	3	6	
h.	Ferruginous sand	-	-	2	0	
g.	Yellow sand, about	-	-	3	6	
f.	Ferruginous sand, about	-	-	0	9	
e.	Whitish sand, about	-	-	1	3	
d.	Clay	-	-	2	0	
c.	Yellow sand, about	-	-	1	6	
b.	Clay, whitish towards the bottom	-	-	2	0	
					19	0
a.	Solid chalk				Feet 70	0

I met with no crag shells in these strata at the pit at Thorpe. About midway between the points G and M, and near the point O, in the ground plan, some of the lower of the above supercretaceous strata were faulted in the manner represented in Fig 6., the greatest perpendicular displacement being about 2 feet :

Fig. 6.*



but those strata in that section, whose vertical distance from the chalk exceeded 16 feet, remained undisturbed and horizontal. From the sequel it will appear probable that this displacement is owing to the occurrence of a sandpipe in the chalk, to the west of the line G M; but the existence of such a cavity was not proved in this instance; for, during my visits to the chalkpit, the clearing of the chalk had not proceeded beyond the line in question.

* The references to this diagram are given in the above table of the strata overlying the chalk.

The second of the two pits above referred to, worked in the solid chalk, lies about 4 miles N. E. of Norwich, a little to the north of Rackheath church. It is on the east side of a north and south valley, which terminates northwards in the east and west valley of the Bure.

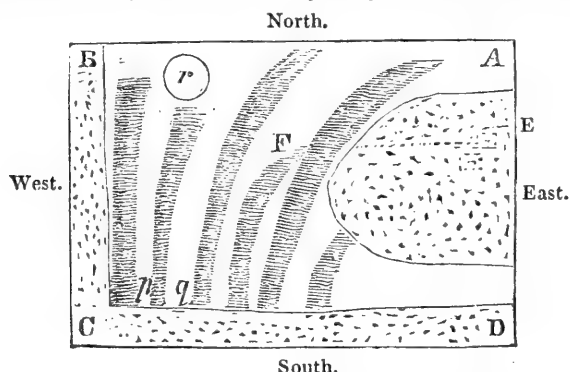
The surface of the chalk is marked by broad undulations, 3 or 4 yards asunder, and about a yard deep, the prevailing direction of these undulations, drawn lengthwise, being north and south; but this direction is liable to exception. The chalk is worked to a depth of from 12 to 18 feet below its own surface, the depth increasing with the distance from the valley. Paramondras, which are generally abundant in the chalk of this part of Norfolk, are particularly so in this pit; and I noticed one of them, having its lower part fixed in the chalk, and its upper enveloped in the sand of the crag, which here covers the chalk.

The crag is from 10 to 18 feet thick; but it thins off towards the valley. The *Pan* rests immediately on the chalk; and above the pan are beds of yellow and white sand, alternating with bands, 2 or 3 inches thick, of gravel and laminated clay. In the spring of 1844, in the progress of the workings, a bed of crag-shells was exposed, about 3 feet long and 2 feet thick, at the height of about 3 feet above the surface of the chalk; and another thin layer of crag shells may be seen in the bank of an adjoining road. The above lower crag strata conform to the irregularities in the surface of the chalk, both where it sinks towards the valley and where it rises above the ordinary level. The valley therefore appears to have been partially excavated in the chalk, before the supra-cretaceous beds were deposited. The upper beds consist of less regularly stratified sand and gravel.

In the beginning of May, 1843, a space, A B C D (see Fig. 7.), bordering on the edge of the valley, 19 yards by 14, was cleared of the sand and gravel, which were here from 10 to 12 feet thick. The surface of the chalk thus exposed was traversed by numerous shallow and nearly parallel furrows, which had a

Fig. 7.

(Ground Plan of the cleared Surface of Chalk at Blackheath.)



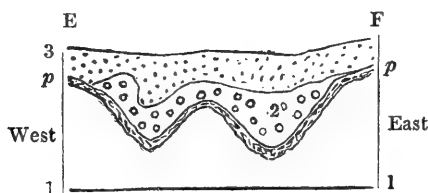
The shaded parts represent the ridge, and the blank parts the furrow.

prevailing direction from N. to S., agreeing with that of the valley; but such a parallelism between the furrows in the surface of the chalk and the nearest valley does not hold as a general rule; for in a space that was subsequently cleared, less than 20 yards from that shown in the diagram, the direction of the furrows was E. and W. Upon the whole, however, the north and south furrows seem to be the deepest.

The deepest of the furrows shown in the diagram, which was *p*, was about 3 feet wide, and 1 foot deep: the next furrow, *q*, was 6 inches wide and 3 deep; and, for the length of 2 or 3 yards, was as clean cut as a gutter-tile. It led to a circular cavity, *r*, 3 feet in diameter, which looked like the mouth of a pipe; but, on removing the sand, it was found to be only 1 foot deep in the centre. The rest of the furrows were broader, shallower, and less regular than the two former, and were lost in a large irregular cavity, not visible at my first visit to the pit, but afterwards exposed to view in a vertical section, passing through the line *E F*, about 12 feet to the south of the line *A B*.

The hollow (see Fig. 8.) thus laid open was about 11 yards

Fig. 8.



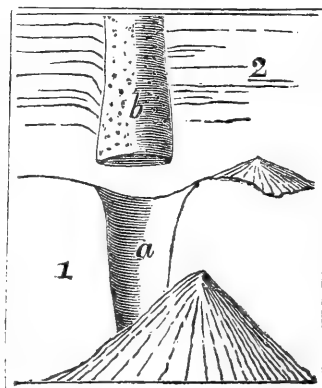
1. Solid chalk.
- p*. Pan, or ferruginous breccia.
2. Sand, black towards the bottom, yellow towards the top.
3. Whitish sand.

wide, and was divided by a ridge of chalk into two cavities, which were respectively 21 and 12 feet wide, and 3 and 7 feet deep. The bottom of this hollow, like the surface of the chalk generally, was lined with the pan; above this, within the hollow, was sand, blackish towards the bottom, but yellow towards the top. Over this and over the Pan beyond the limits of the cavity, was a whitish sand.

In other parts of the Rackheath pit, several sections of deep pots were visible; and one of the most remarkable of these is represented in Fig 9.

"Core" is the term given by the workmen to the column of unstratified, tenacious, gravelly loam, which is sometimes found over a "pot" in the chalk, rising through and traversing the regularly stratified and alternating bands of sand, gravel, and clay, belonging to the crag and overlying the chalk. One of these cores, projecting *in relief* above the strata of the crag, is represented in the annexed diagram. On one side, the laminae of stratification bend

Fig. 9.



1. Solid Chalk.
2. Sand, gravel, and clay.
- a. Pot in the chalk.
- b. Core above the pot.

down towards the core; on the other, they abut abruptly, in a horizontal position, against it.

Over the larger sand-pipes in this pit generally, the stratification of the lower beds of crag is disturbed, and, in some places, quite obliterated.

From the state of the strata of the uncallow above, the workmen profess to be able to determine the nature of the cavity in the chalk below. It may be stated, as a general rule, that over "drops," or other irregularities in the surface of the chalk, of greater width than depth, the alternating beds of sand and clay are disposed in gently curving flexures, which are evidently original conditions of deposit: that over deep pipes, not exceeding a foot in diameter, the laminæ of the sand and gravel are undisturbed; that over pipes of greater diameter the laminæ usually suffer disturbance; but that even over the widest pipes, the disturbance does not extend to the height of 20 feet from the surface of the chalk. When the Uncallow exceeds that thickness, the disturbed strata are overlaid by others which are horizontal.

Among the contents of the sand-pipes in the solid chalk near Norwich, I have not met with any fragments of chalk; though in two instances I have seen rounded pebbles of chalk, lying near the clay which usually lines the sides of these cavities. The flints in the pipes are rarely waterworn, and appear to have been rarely detached from the chalk. In Kent, on the contrary (particularly in a pit near Canterbury, described by me in a former communication) a large portion of the flints in the pipes have undergone considerable attrition; but the form of the pebbles is not orbicular nor ellipsoidal, but rather that of two cones, placed base to base.

As a general fact, crag-shells have not been found in the pipes in the solid chalk near Norwich, even in cases where such shells are abundant in the overlying crag strata. Neither have I dis-

covered in these pipes any mammalian bones, nor have I learned that any such discovery has been made by others.

I have now to describe some sand-pipes near Norwich, not in solid chalk, but in reconstructed chalk or chalk-rubble.

The pit in which these occur is at Crostwick, about five miles N. E. of Norwich, on the western side of Rackheath Valley, and at its point of confluence with the valley of the Bure. The dimensions of the pit are about 35 yards by 48 and the sections of its southern, eastern, and western sides, are represented in the three following diagrams :—

Fig. 10. CROSTWICK PIT.

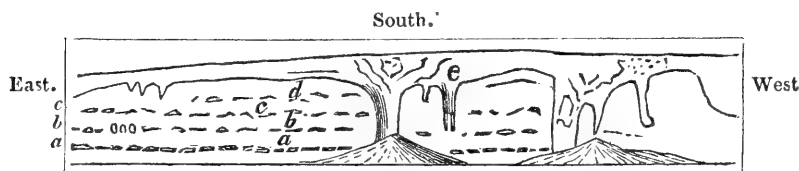


Fig. 11.

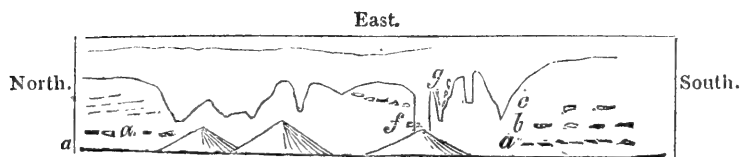
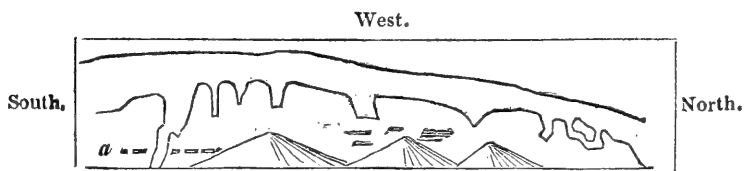


Fig. 12.



Note.— The references to the above three diagrams are as follows :—
a, b, c, d. Various layers or seams of flint in the gravel and sand overlying the chalk (*Uncallow*).

e. A pipe which divides into two cylinders.

f. A flint protruding from the chalk into a sandpipe.

g. Various flints (not in layers) in the uncallow.

Various irregular seams of clay also occur in different parts of the uncallow, as near *e* in fig. 10. (to the right of that letter); to the left of *f* in fig. 11.; and where lines are represented in fig. 12.

Seams of crag shells also occur at two or three points near *b* in fig. 10. and above *f* in 11.

The lowest line of flints, marked *a, a*, runs with great regularity all round the pit; and must, I think, be in solid undisturbed chalk. The next line (*b, b*) is less regular and continuous; but it

contains two Paramoudras, in their proper vertical position. The third line (*c, c*) is more irregular, and some of its tabular masses of flint lie horizontally, while others stand up vertically; and a little below this line, on the southern side, are some irregular lines of gray clay, with a ferruginous tinge. Above the fourth line of flints (*d, d*) to the west of the middle point of same side, a seam of similar clay is continuous for several feet.

On the eastern side, towards the north end, similar seams of clay occur above the lowest line of flints (*a, a*), at intervals of from 6 inches to 2 feet in perpendicular height. They are rarely more than 6 inches long, and an inch thick. Several seams also occur about the middle of the same side, below the level of the third line of flints (*c, c*). Irregular seams of clay and sand appear also about the middle of the western side of the pit; and these occasionally expand into masses of sand, 6 inches long and 2 or 3 inches thick. The seams of clay dip, on the south side toward the north, on the east side toward the east, and on the west side toward the west. In the north-east corner of the pit, the reconstructed chalk rises to the height of 12 feet above the level of the lowest line of flints (*a, a*).

Near the middle of the eastern side of the pit, at the depth of about 5 feet below the surface of the reconstructed chalk, a layer of crag shells occurs, about 10 feet long, dipping eastward. The general thickness of this layer is from 1 to 3 inches; but in one part, for the length of 2 feet, it swells out to the thickness of 1 foot; and the shells are here mixed with sand and a few pebbles. Among the shells, which are chiefly in large fragments, Mr. Wigham recognized *Astarte plena*, *Tellina obliqua*, and *Cyprina islandica*, the last shell being the most abundant.* I have before stated that the pan which underlies the fluviatile deposit of Mundesley, and the bed which overlies the fluviatile deposit at Runceton Gap, agree as to the species of shells which they contain; and it becomes a question with which of these two beds the crag of Crostwick was contemporaneous.

So solid in appearance is the reconstructed chalk of this pit, that, until I discovered the above described layer of crag shells, I had no suspicion that it was any thing but solid chalk; and even now, when I am convinced that a large portion of the matter in which this pit is excavated is chalk-rubble, I am unable to assign, with any degree of precision, the limits between the reconstructed and the solid chalk. The fragments of chalk in the rubble of Crostwick do not exhibit the slightest appearance of attrition.

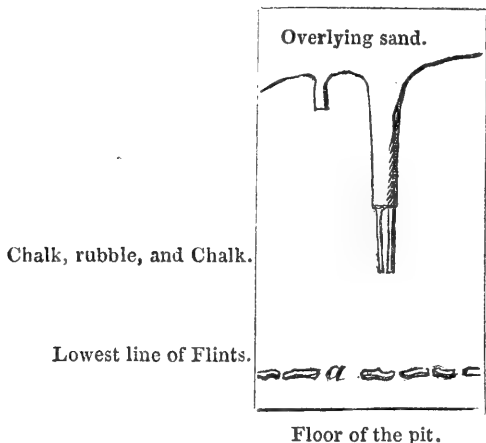
As to the deposits above the reconstructed chalk, they rise to the height of about 4 feet above the general level of the latter. Of the Pan there are no distinct traces. The lower of these overlying deposits are more regularly stratified than the upper.

* The entire skeleton of an elephant was found some years ago, as Mr. Wigham informs me, in a pit of chalk-rubble in the neighbourhood of Crostwick; and, as he believes, in this very pit. In this part of Norfolk, "marl" is the name which the farmers give in common both to chalk and to chalk-rubble.

One of the most remarkable phenomena in this pit is to be observed on its southern side. A cylindrical pipe (*e*), of small diameter, divides into two smaller cylinders, two or three inches in diameter each. They are separated one from the other by an interval of 2 or 3 inches, and each holds an uninterrupted course through the chalk to the depth of several feet. In this and in other instances of the same kind that I have met with in Norfolk, the division of the pipe into two branches appeared to have been caused by a flint obstructing nearly the whole area of the pipe;

Fig. 13.

South side.



and the diameters of the smaller cylinders into which it divided appeared to be influenced by the size of the apertures left in the mass of flint.

In another pipe on the east side of the Crostwick pit, a flint (*f*), is seen, one part of which remains imbedded in the chalk, while the other part projects into the cavity of the pipe. The upper surface of the projecting part has indications of wear, while its under surface retains the original chalky coating.

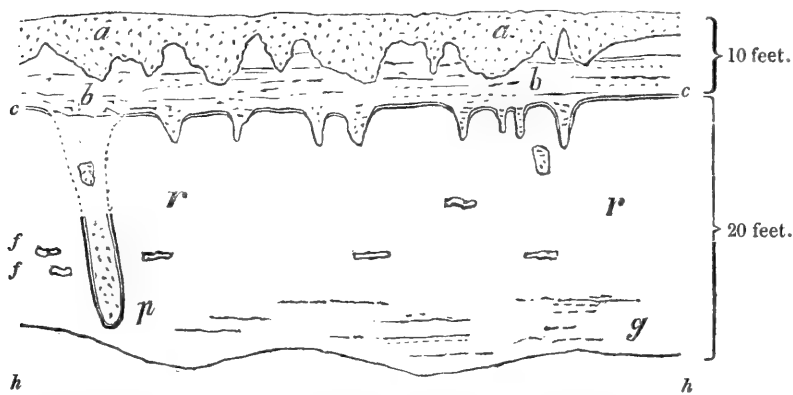
In another part of the same pit I observed fissures radiating from one of the pipes; and these fissures were filled with the same fine clay with which the pipes are usually lined. I have since met with similar fissures, similarly lined, in pipes traversing the solid chalk: they occur in pits in this part of Norfolk.

In a paper on the detrital deposits of part of West Norfolk, (Proceedings of the Geol. Soc. vol. iii. p. 185.), I showed that the chalk is there covered by two deposits of very variable thickness. The upper consists of ferruginous sand or loam, and of numerous chalk flints, which have undergone scarcely any abrasion, together with a few fragments of other rocks, such as trap, porphyry, &c., which indicate distant transport: and with these ingredients, beds of rolled chalk-pebbles are occasionally associated. The lower deposit consists mainly of fragmentary chalk, which has undergone

very little attrition ; and sometimes this constitutes almost the sole material ; sometimes there is an admixture of a variable proportion of sand and clay. The lower deposit, though very generally distributed, is more local than the upper. There can be no doubt that both belong to the northern drift.

The surface of the lower deposit is often very much eroded with conical and cylindrical pipes, and with irregular furrows from a few inches to a foot or two in width, and rarely more than 3 or 4 feet in depth. I gave in the same paper an instance of this at Gallows Hill, near Burnham Market, on the side of a valley which opens to the sea, and is excavated in the solid chalk. This

Fig. 14. BURNHAM MARKET.



- a.* Ferruginous sand, with unabraded flints, and pebbles of trap and porphyry.
- b.* Lighter-coloured gravel, with angular flints, rounded pebbles of chalk, and pebbles of trap and porphyry.
- c.* Where the lining is darker, is a lining of clay. This lining extends also round the sand-pipe *p*.
- r.* Comminuted chalk, mixed with clay and sand, and with rounded and partially waterworn fragments of chalk.
- f.* Large tabular unabraded masses of flint.
- g.* A bed of gravel.
- h.* Solid chalk.

mass (*r*, *r*) was 20 feet thick, and consisted of finely-comminuted chalk detritus, mingled with clay and sand, and containing rounded and slightly waterworn fragments of chalk, and large tabular flints, not in the least abraded. It had seams of sand, several inches thick, in its lower part ; and one of these expanded into a bed of gravel 2 feet thick. It was traversed by a sand-pipe (*p*), which appeared to extend through its entire thickness.

In a recent communication I mentioned a bed of chalk-rubble near Trimmingham, which occurs enveloped in drift, and is so pure as to be burned for lime. I have since met with another such deposit near the Thorpe entrance to Gunton Park, which is also burned for lime : it consist of fragments of chalk which have undergone some little attrition. This bed is from 12 to 15 feet thick ; rests upon sand ; and is covered by from 2 to 4 feet of

sandy loam. In an area from which the uncallow had been recently cleared, 15 yards long, and from 3 to 5 yards broad, I found the surface of this bed honeycombed with sand-pipes, which were from 1 to 3 feet deep, and scarcely 2 feet apart. They were connected by furrows running in various directions.

From the phenomena above recorded as occurring in Norfolk, combined with those which I formerly observed in Kent, it may be concluded, that the surface both of the solid and reconstructed chalk in those counties has been exposed to the action of which sand-pipes are the result; and this at various epochs, extending from a period prior to the deposit of the sands of the plastic clay, to the close of the period of the stratified drift.

The phenomena, observable in Norfolk, of the horizontal strata of sand and gravel, superincumbent on the chalk, bending down into the cavities of the larger sand-pipes as they approach those cavities, led Mr. Lyell to attribute these irregularities to the gradual removal of the chalk after the sand and gravel had been deposited; and the agent by which he supposed the chalk to have been removed, was acidulated water, percolating the overlying deposits, which deposits subsided into the hollows beneath, on their losing their support.

That a certain amount of subsidence has, in many instances, taken place, I am by no means disposed to deny; and we have evidence of this in the vertical striæ which I have often observed on the walls of pipes, and which I find, from the paper of Mr. Rose on the geology of West Norfolk, that he has also noticed. The faulted state of the bands of sand and clay at Thorpe, represented in Diagram 6. (supposing that fault to be attributable to some neighbouring sand-pipe), may also be adduced in proof of the subsidence of the strata into those cavities.

I believe these cavities to have been formed before the superincumbent strata were deposited. The shallow circular basins observed on the surface of the chalk at Thorpe and Rackheath, and formerly also in Kent, I consider as incipient pipes. The formation of such hollows in siliceous blocks on the sea-shore, by the rotation of sand and water, I formerly pointed out in my paper on the sand-pipes of Kent. I have also observed miniature furrows, and conical and cylindrical cavities, now forming on chalk, by the action of sand and water, on the coast of Norfolk, between high and low water mark. These cylindrical cavities are 2 inches in diameter, and 4 inches in depth.

I beg to compare the sand-pipes in the chalk with the rock-basins worn in the river-beds of gneiss and granite in Southern India, of which Lieut. Newbold has given an account. (Proceedings of the Geol. Soc., vol. iii. p. 702.) These cavities are from 4 inches to 4 feet in diameter, and 4 feet deep; and they are connected one with another by shallow channels. For the further details on this subject, I beg to refer to the abstract of his paper.

The effect of cavities, when once formed in the bed of a rapid river or tide, is to occasion whirlpools, which set in rotation the

matters within the cavity, the heavier bodies remaining within it, while the lighter are ejected. In this way, it appears to me that pits in the chalk may have been kept open for some time after the deposit of the crag had commenced.

The bending down of the lower strata of the crag into the hollows of the larger and deeper pipes, may be regarded as an extreme case of the stratification conforming itself to pre-existing irregularities of surface, a conformity which is so apparent in the same strata when extending over the broad and shallow hollows in the chalk. A subsidence to a limited extent in matters so deposited is not incompatible with the mode and circumstances of their deposition.

January 8. 1845.

George Dawson, Esq. of Birmingham, was elected a Fellow of this Society.

The following communications were read:—

1. *On the Discovery of the Fossil Remains of BIDENTAL and other REPTILES in SOUTH AFRICA.* By ANDREW GEDDES BAIN, Esq.* Surveyor of Military Roads under the Corps of Royal Engineers.

THE district in which these fossils were found is on the eastern frontier of the Cape Colony in South Africa, about 500 miles east of Cape Town. No granite has been observed here, and the lowest rocks are stratified, and in consequence of the dip, though variable, tending on the whole towards the interior of the country, the lower members of them are those nearest the coast.

A red quartzose crystalline sandstone is described by the author as the fundamental rock, and as alternating with a talcose slate. This sandstone is assumed to be of the carboniferous period, vegetable impressions, apparently of a *Lepidodendron*, having been found in it, and it is traced by the author towards the west, parallel to the coast to within 50 miles of the Cape.

Over this there occurs a rock, called by the author a claystone porphyry, containing fragments of the sandstone; next an argillaceous slate, alternating with sandstone and containing thin laminæ of limestone, and at a little distance is a stratum full of vegetable remains.

Further to the north is a ferruginous sandstone with argillo-calcareous nodules, in which nodules were found the remains of reptiles characterised by the author as *Bidental*, and described by

* This and the succeeding memoir are published *in extenso* in the Transactions of the Geological Society, 2d series, vol. vii. p. 53.

Professor Owen in the subsequent memoir. From the basin of Fort Beaufort to near the southern foot of the Winterberg range (which is about 90 miles inland) the same beds appear to be continuous, but they are interstratified with beds of greenstone which also occasionally intersect them.

The Winterberg peak (between 5,000 and 6,000 feet high) is a flat tabular mass of basalt. Several hundred miles to the westward of the peak a region extends of horizontal sandstone capped on the eminences by basalt and intersected by numerous basaltic dykes. A similar region extends to the north of the peak. Here again reptilian fossils have been discovered, and they have also been brought from the country far to the north beyond the Orange River. Ammonites have been found at the summit of the Compass-berg 150 miles N.W. of the Winterberg.

The author does not venture to decide on the geological age of the formations he thus describes, but proceeds in conclusion to allude to some overlying deposits found near the southern coast of Albany, one of which is a red sandstone conglomerate, entirely without fossils and resting unconformably on the supposed carboniferous sandstone: others are distinctly tertiary, and abound in shells resembling those of animals still living on the South African coast. A thick diluvial deposit is found near Fort Beaufort, and from the plains far to the northward beyond the Orange river the fossil skull of a kind of buffalo has been obtained.

2. *Description of certain Fossil Crania, discovered by A. G. BAIN, Esq., in Sandstone Rocks at the South-eastern Extremity of Africa, referable to different Species of an extinct Genus of Reptilia (DICYNODON), and indicative of a new Tribe or Sub-order of SAURIA.* By RICHARD OWEN, Esq., F.R.S., F.G.S., &c.*

THE most remarkable character in these fossils is the presence of two long curved and sharp-pointed tusks, which, like those of the Walrus, descend one from each superior maxillary bone, and pass on the outside of the fore part of the lower jaw, a character rare even in Mammals, and hitherto only met with in that class; but in these specimens combined with a structure of the cranium, proving that the animals belonged to the class Reptilia, but were members neither of the Crocodilian nor Chelonian orders. The Lacertine Sauria offer characters for comparison, but the minor deviations from the ordinary Lacertian structure are so numerous, the mode in which Crocodilian and Chelonian characters are interwoven upon an essentially Lacertian base is so interesting, and the individual and distinctive characters of the Dicynodons so striking and peculiar as to require a detailed osteological description for their complete illustration.

* Transactions of the Geological Society of London, 2d series, vol. vii. p.59.

In these animals, the Crocodilian structure is chiefly manifested in the occipital region of the skull, and gives place to the Lacertian characters in the upper and fore part ; but in regard to these deviations it must be remembered, that the distinctive features of the Crocodilian type are most broadly manifested in the existing representatives of the order, and are modified and rendered less salient in the more numerous and varied extinct members.

It is necessary to bear in mind this tendency to the amalgamation of Crocodilian and Lacertian characters in the older Loricata, in order to form a right estimate of the value of those correspondences with the cranial peculiarities of the existing Lacertians.

Nevertheless, various characters justify the conclusion, that the general type of cranial organisation manifested by modern lizards was that in which the peculiar modifications of the Dicynodon have been superinduced. It is not, however, amongst the modern lizards that we find the nearest approximation to the Dicynodon. For this we must go as far back into the period of Reptilian life on this planet as the epoch of the new red sandstone, when the *Rhynchosaurus* manifested the Lacertian type of skull, combined with toothless jaws, which were most probably sheathed with horn. What concerns us most in the present inquiry is the anomalous edentulous sharp edge of the upper and lower jaws in the ancient Rhynchosaur, and the Chelonian form of the deep lower jaw, the same anomaly having been repeated in the extinct African lizard of apparently as remote a period, with the superaddition of Mammalian canine tusks. For the rest, much difference of form is manifested in the two extinct genera ; but it is interesting to remark the same peculiar contraction of the cranial cavity, indicating an arrested development of brain in both of them. The dental peculiarity of the African Saurian forms its chief distinction from the Rhynchosaurus, as from all other Sauria : but with the strange superaddition of its two canine tusks, we must bear in mind that the affinities linking the Dicynodon to Crocodilians and Chelonians are much more strongly manifested than they are in the Rhynchosaurus.

The author, in concluding his account of the Dicynodon, adverts to the analogy of structure, which radiates from this genus in the direction of the Ophidian division of existing Reptilia, although it is unsupported by any other concordances of cranial or dental organisation than those about to be cited. In the poisonous serpents, the rattle-snakes for example, the intermaxillary bone is single and edentulous ; the maxillary bone supports a long, curved, pointed tooth, which, when advanced, descends outside the lower jaw. Apart from all the other peculiarities of the maxillary and dental systems of the poison-snakes, they alone, of all existing Reptilia, repeat, in the above-cited structures, the characters of the Dicynodon. But, in addition to the two large maxillary teeth, the rattle-snake has smaller

teeth in rows upon the palatine, pterygoid and mandibular bones. To complete the resemblance between the tusks of the Dicynodon and the venom fangs of the snake, you must deeply groove their fore-part, or bore a canal through their centre; you must remove those strong columns of bone which converge to, abut against, and strengthen the fixed socket of the tusk, and you must suspend the maxillary bone by a moveable pedicle to the pre-frontal and malar bones. Besides, the perforated tusk of the poisonous serpent is always followed by one or more similar teeth, in various stages of growth, ready to supply its place, according to the general law of the maintenance in serviceable state of the dental armature of the jaws throughout the Reptilian class.

The canine tusk of the Dicynodon consists of a simple body of compact unvascular dentine, with a very thin outer coat of enamel, which may be traced into the alveolus for a short distance. Rather more than one-third of the tusk is lodged in the socket, the basal conical pulp-cavity is continued from the base about one-half down the implanted part of the tusk, and a linear continuation extends along the centre of the rest of the tusk, from which the dentinal tubes of the solid body of the tusk radiate. They present gentle parallel secondary curves or undulations throughout their course, divide dichotomously twice or thrice near their beginnings, and send off numerous small lateral branches, chiefly, but not exclusively, from the side next the apex.

The principal difference in the microscopic texture of the tusks of the Dicynodon, as compared with the teeth of the crocodile, consists in the closer and more compact arrangement of the calcigerous tubes of the dentine; by which character it makes a closer approach to the intimate texture of that tissue in the canine teeth of the carnivorous Mammalia.

In the other Reptilia, recent or extinct, which most nearly approach the Mammalia in the structure of their teeth, the difference characteristic of the inferior and cold-blooded class is manifested in the shape, and in the system of shedding and succession of the teeth. The dental armature of the jaws is kept in serviceable order by uninterrupted change and succession; but the matrix of the individual tooth is soon exhausted, and the life of the tooth itself may be said to be comparatively short. Evidence of this low organised dental condition, common to fishes, has been obtained in every reptile, in which the implanted base of the teeth has been examined by the author.

The existing Lacertians superadd to this endless shedding and succession of teeth, the ichthyic character of ankylosis of the base of the teeth in use to the osseous substance of the jaw; so that in the *Rhynchocephalus* and other acrodont lizards, the teeth appear like small enamelled processes of the alveolar border. The Dicynodons not only manifest the higher type of free implantation of the base of the tooth in a deep and complete socket, common to Crocodilians, Megalosaurus, and Thecodonts, but make an additional

and much more important step towards the Mammalian type of dentition by maintaining the serviceable state of the tusk by virtue of constant renovation of the substance of one and the same matrix, according to the principle manifested in the long-lived and ever-growing tusks and scalpriform incisors of the Mammalia. This endowment of the teeth of a reptile is far more remarkable and unexpected than the more obvious character of the size and shape of the long exserted tusks themselves, superadded as they are, and in such strange combination, with the otherwise edentulous jaws of a bird or turtle. Yet if we consider the fact in its relations to the exigencies and convenience of the living animal, the wisdom and beneficence of the principle is apparent, and the departure from the ordinary rule manifests a power transcending the trammels of scientific system. The teeth of the *Dicynodon* being but two in number, and their use to the animal indicated by their unusual size to be of unusual importance, the inconvenience and detriment that must have ensued from frequent shedding and replacement is very obvious; we may readily conceive it to have been incompatible with their functions, and therefore abrogated in favour of another mode of renovation which is abnormal in reptiles, simply, perhaps, because the form, proportions, and function of such tusks were unique, and are now no longer manifested in a cold-blooded class.

Some observations may be naturally expected in reference to the probable use of the tusks to the *Dicynodons*, and the mode of life of those ancient and most remarkable saurians. In the Mammalian class, where alone we now find the analogous instruments, tusks are usually given as weapons of offence and defence, — an office exemplified in the hornless musk-deer, the boar, and in the large canine teeth of the Carnivora. The elephants use their tusks chiefly, though not exclusively, as lethal weapons: the Walrus is said to apply his tusks to aid in clambering over icebergs, as well as in combat and defence: the Dugong is supposed to wear the exserted points of the tusks in detaching fuci for food. Such an office at first suggests itself as a very probable one in regard to tusks descending, like those of the Dugong, from the upper jaw, and combined with edentulous and probably horny mandibles like those of a fucivorous turtle.

On inspecting the remains and the impressions of the tusks in the fossils under consideration, and especially in the almost entire skull of one species, the *Dicynodon lacerticeps*, we perceive that these weapons are sharp-pointed, and present no trace of that obliquely bevelled or chisel-shaped extremity which is produced by habitual application in acts of obtaining daily food, as, for example, in the protruded extremities of the tusks of the Dugong and the incisors of the Rodents. The tusks of the *Dicynodon*, though similar, in their origin from maxillary bones and downward direction, to the tusks of the Walrus, are so much shorter, at least in the single specimen in which their entire length is shown, that they could not be available in locomotion. I conclude therefore from their shape, pro-

portional length, sharp points and dense texture, that the tusks of the Dicynodon were applied by the living animal either for the purpose of killing its prey, or of defending itself from its foes, or in both acts; and that they were offensive and defensive arms.

A further insight into the habits and mode of life of the Dicynodons may reasonably be expected to follow the examination of the skeleton of the trunk and the organs of locomotion. This will form the subject of a subsequent memoir; but the vertebræ of the Dicynodon present the sub-biconcave structure common to most of the older extinct saurians, which structure, in comparison with the ball and socket vertebræ of the modern species, indicates a more aquatic and perhaps marine theatre of life for the amphibia which swarmed in such plenitude of development and diversity of forms during the ancient secondary periods of the geological history of this planet.

JANUARY 22. 1845.

David Walter, Esq., of Colchester, was elected a Fellow of this Society.

The following communications were read:—

1. *On the Newer Coal Formation of the Eastern Part of NOVA SCOTIA.* By JOHN DAWSON, Esq.

IN some notes communicated last year to the Geological Society, I stated the results of observations on the gypsiferous formation of Nova Scotia, tending to confirm the views of Mr. Lyell respecting the age of that series of rocks. In introducing those notes, it was stated that the carboniferous strata of this province may be included in three groups; first, the gypsiferous or mountain limestone formation; secondly, the older coal formation; and thirdly, the newer coal formation: of these the two former have almost exclusively attracted the attention of geologists, the latter having been in a great measure neglected. In connection with the Pictou coal field, however, and probably also in other parts of this and the neighbouring colonies, the newer coal formation is an extensively distributed deposit, often attaining considerable thickness, and, though not containing valuable beds of coal, ironstone, or gypsum, yet so associated with the rocks including these minerals, that a knowledge of its structure and relations is essential to their satisfactory investigation. In a palæontological point of view also it possesses considerable interest; as its fossils show the continuance of the coal flora during the deposition of a series of red sandstones newer than the great coal measures; and also the co-existence of that flora with terrestrial vertebrated animals.

The coal measures of the Albion mines, on the banks of the

East River of Pictou, a series of beds, estimated by Mr. Logan at 5000 feet in thickness, and constituting our older coal formation, are succeeded, in ascending order, by a great bed of coarse conglomerate, which, as it marks a violent interruption of the processes which had accumulated the great beds of coal, shale, and ironstone beneath, and as it is succeeded by rocks of a character very different from that of these older coal measures, forms a well-marked boundary, which we may consider as the commencement of the newer coal formation.

This conglomerate appears in the East River section, at New Glasgow, where it dips to the north. From this place its outcrop, rising above the neighbouring softer rocks, may be traced, in a western direction, as far as the West river, nine miles distant, and eastward for a few miles, when it either disappears beneath the surface, or passes into red sandstones, which appear in the same direction, as far as Merigomish Harbour, six miles distant.

On the East River the conglomerate is accompanied and overlaid by soft reddish sandstones. Northward of New Glasgow, however, the banks of the river are covered with detritus, and the only rocks which appear are grey sandstones and grey and reddish shales, which are seen in a few places. In one part of the section numerous fragments of black shale, with coprolites and scales of ganoid fishes, appear to indicate the presence, in this series, of a bed of that description. Wherever the dips of the rocks, on this section, can be ascertained they are northerly, but usually at a very small angle.

Eastward of the Ewer section, and in geological position probably a few hundred feet above the conglomerate, there is a bed of grey limestone, twelve feet or more in thickness, containing a few minute univalves, and having in one part of its thickness a peculiar laminated and concretionary structure. Above this limestone, and separated from it only by a few inches of underclay, is a small bed of coal. The outcrop of these beds can be traced across the country, parallel with that of the conglomerate, as far as Merigomish Harbour, where they are seen dipping to the north at an angle of about 25° , and are accompanied by reddish and grey sandstones and shales. The latter rocks form a series of at least 2000 feet in thickness, portions of which appear at various places on the shores of Merigomish and Little Harbours. Red sandstones prevail in the lower part of this series, but in its upper portion there are thick beds of grey sandstones, accompanied by grey shales; and, in one place, by a bed of coal 11 inches thick, with an underclay. They also include a thin bed of dark grey limestone, in concretionary balls, separated by clay. Near Merigomish, these beds dip to the north at an angle of about 20° , but further westward the dip becomes very small, and they spread over a greater surface, so as to occupy the shore nearly as far as the entrance of Pictou Harbour. In the grey sandstones on this shore, coniferous wood, fossilized by carbonate of lime, is very abundant; and *Calamites*, *Endo-*

genites, *Lepidodendron*, and carbonized vegetable fragments are frequent.

Northward and westward of Pictou Harbour, is a series of rocks, nearly resembling those just described, and generally dipping to the south-east, at angles of 15° to 25° . In Rogers Hill, six miles westward of Pictou, are thick beds of coarse conglomerate, considerably disturbed, associated with greenstone and hard claystone, and showing, in one part, a thick vein of crystalline sulphate of barytes. This conglomerate I believe to be geologically identical with that of New Glasgow. It is succeeded by a great series of deposits, chiefly consisting of reddish sandstones and shales; but including several thick beds of grey sandstone, affording quarries of valuable grindstone and freestone, and accompanied by grey shales, conglomerates, thin beds of coarse limestone, and a thin bed of coal. As there are no very good natural sections in this part of the country, it would be difficult to ascertain the aggregate thickness of these deposits; it must, however, be great, since they occupy, with general south-east dips, the whole country from the hills last named to the entrance of Pictou Harbour. The principal fossils found near Pictou, are *Calamites*, *Lepidodendron*, *Endogenites*, coniferous wood, ferns, *Sternbergia*, and carbonized fragments of wood impregnated with iron pyrites and with sulphuret and carbonate of copper. In this series, also, and near the town of Pictou, is the bed of sandstone containing erect calamites, noticed by Mr. Lyell in his papers on the fossil trees of the Joggins. A section of the rocks accompanying this bed is annexed.

SECTION of rocks of the NEWER COAL FORMATION at DICKSON'S MILLS
near the town of PICTOU (330 yards).



5. Coarse reddish sandstones with finer reddish and grey beds and shales, especially in the lower part. *Ferns* and *Stigmariæ*.

4. Brown conglomerate not coarse.

3. Reddish sandstones and shales.

2. Grey sandstone coarse above and finer below (thickness 50 ft.), in upper part prostrate *Calamites* and *Lepidodendron*; lower part erect *Calamites*, concretions of impure limestone with calamites and endogenites succeeding the sandstones.

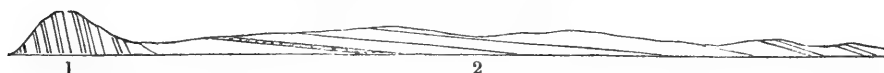
1. Reddish sandstones and shales with fucoid marks and impressions of ferns.

The coast section, westward of the entrance of Pictou Harbour, is for some distance very imperfect. Much red sandstone, however, appears; and a bed of limestone from two to three feet thick, and a small bed of coal, have been discovered. Some grey sandstones also appear: in one of which, of a coarse pebbly texture, there are numerous fragments of carbonized wood, containing sulphuret and carbonate of copper. This deposit and others of a similar nature, found in this series at various places, have given

origin to hopes, probably delusive, that valuable deposits of that metal might be found in our newer coal formation.

Beyond Fowey River, ten miles north-westward of Pictou, the coast affords a good section, exposing reddish sandstones and shales, containing some grey beds in their upper part, and including a thin bed of dark grey limestone. Some of the red shales contain leaves of ferns and fucoidal marks. The dip of these rocks is to the S.S.E., at a very small angle: on approaching Cape John, however, the angle of inclination becomes greater, and grey beds again become numerous, some of them being thick-bedded and coarse-grained sandstones, and containing calamites and carbonized wood. At the extremity of the Cape the strata becomes vertical, and here (but below low-water mark) is a bed of white granular gypsum, about three feet in thickness. The rocks in which this small bed is situated, must belong to the newer coal formation, and probably to its lower part; and it is the only instance with which I am acquainted, of the occurrence of gypsum in that part of the carboniferous system. As it appears in none of the other sections which I have examined, the range of this bed is probably small, and it is too unimportant in thickness, to invalidate the claim of the older carboniferous deposits to the title of *gypsiferous* series.

COAST SECTION of the NEWER COAL FORMATION from CAPE JOHN,
8 miles to the Southward.

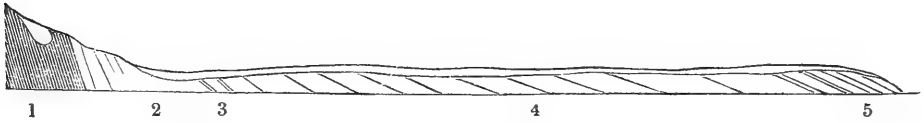


2. Reddish sandstone and shale with grey beds and limestone, containing ferns, *Sphenophyllum* and *Lycopodium*.

1. Grey and reddish sandstones and shales with conglomerate and gypsum. *Lignite* and *Calamites*.

Beyond Cape John, a band of comparatively level country, skirting the shores of the Gulph of St. Lawrence, and extending as far as Wallace Harbour, is occupied by the newer coal formation, which here contains a greater proportionate abundance of red sandstones than near Pictou; and instead of being bounded on the inland side by carboniferous rocks, is met by, and seems to overlie unconformably, a series of hard grits, slates, and limestones, with scales of *Holoptychius*, *Encrinites*, and fragments of bivalve shells, and which are probably of Newer Silurian or Devonian age. The last mentioned rocks, with various kinds of trap, form an elevated ridge belonging to the Cobequid chain of hills. A copy of the section exposed by the French river of Tatmagouche, which was described in my paper of last winter, and well illustrates the structure of this region, is annexed.

SECTION OF FRENCH RIVER of TATMAGOUCHE (6½ miles).



5. Grey and red sandstone and shale. *Calamites*, &c.
4. Red sandstones and shales with a few grey beds.
3. Light grey and red sandstone and shale.
2. Slate, limestone and grit with scales of *Holoptychius*.
1. Trappean rocks.

When examining the red sandstones, near Tatmagouche, last summer, I found in one of the beds a few footmarks of an unknown animal, specimens of which were sent to this society. They were mere scratches made by the points of the toes or claws, and therefore could give few indications of the form of the feet which produced them. Their arrangement, however, appeared to indicate that the animal was a biped, and their form is quite analogous to that of the marks left by our common sandpiper, when *running* over a firm sandy shore. On a subsequent examination of the same place, I found a series of footmarks of another animal, and obtained a slab with casts of eight impressions, which I send with this paper. In this specimen the tracks are somewhat injured by the rain-marks which cover the slab, and the clay in which they were made was probably too soft to give good impressions; it has, however, preserved a furrow which must have been caused by the body or tail of the animal trailing over it. Many of the beds in the neighbourhood of that containing these footmarks are rippled, rain-marked, or covered with worm tracks; and as such indications of a littoral origin are not infrequent in other parts of the newer coal formation, it may be anticipated that many interesting relics of terrestrial animals will in future be discovered. At present, however, as no quarrying operations are carried on in the red beds, it is difficult to obtain access to the surfaces on which tracks might be expected to occur. The only vegetable remains found in the red sandstones of Tatmagouche are some of those irregular branching stains which have been considered as fucoidal marks; but in a bed of grey sandstones above the strata containing tracks, I found *Calamites*, *Endogenites*, *Stigmara ficoides*, and fragments of carbonized wood. In a fragment from a dark calcareous bed near this place, I found a portion of a fossil plant covered with shells of a species of *Spirorbis*, and a few small scales of ganoid fishes. A bed of limestone, similar to that of Cape John, has been observed in the sandstones of Tatmagouche, but no coal, gypsum, or conglomerate have been seen. It is probable that most of the sandstones and shales, seen in the French river section, are equivalent to the newest of the strata seen near Pictou.

To give more precise views of the composition and appearance of the newer coal formation, and of the differences between it and

the lower carboniferous series, it may be useful shortly to describe the various rocks of which it is composed.

The *red sandstones* are of various shades, from brick red (which is not common) to reddish brown. They scarcely differ, in their range of colours, from those of the gypsiferous formation, except that in the latter purplish tints are more frequent. They are often flaggy and micaceous, and obliquely laminated, and there is every gradation, from very coarse sandstone to shale.

The *red shales* are generally laminated, but not finely; occasionally, but rarely, they want lamination and then can scarcely be distinguished from the fine sandstones and mudstones which, in the gypsiferous formation, have been named marls. They often have greyish fucoidal marks, and sometimes remains of land plants. The red sandstones and shales are usually soft, and I have nowhere seen them attain the hardness so often found in the similar rocks of the gypsiferous formation.

The *grey sandstones* vary in colour from neutral grey to brownish and yellowish tints; the latter owing to the decomposition of iron pyrites. The sandstones are sometimes coarse, and full of white quartz pebbles, but are more frequently of finer texture. They are accompanied by greyish shales and clays, and the groups of grey sandstone and shale, occurring in the newer coal formation, are much more important than those of the gypsiferous series. These groups of grey beds are always accompanied by thin layers of coarse grey limestone, usually wedge-shaped, and consisting of a basis of sand cemented by lime, containing concretions and small fragments of argillaceous limestone. These coarse limestones, and the sandstones with which they are associated, are always much harder than the red-coloured beds.

From the constant existence, in the grey sandstones, of carbonized plants with sulphuret of iron, it may be inferred that this sulphuret has been produced by the decomposition of the sulphates in sea water, in consequence of the action of decaying vegetable matter, and the combination of their sulphur with iron derived from the surrounding deposits (a process now taking place in many estuaries). By supposing the bleaching of red sands and clays to have been effected in this way, we should, perhaps, account for the connection of fossil remains with grey beds, and for the comparative absence of red tints from the highly carboniferous rocks of the older coal formation.

There are at least two beds of limestone in the newer coal formation, quite distinct from the impure sandy layers before noticed. The principal stratum, that seen near New Glasgow, is of a grey colour, in some places very dark; its structure varies in different parts of its thickness, being flaggy above, concretionary below and in the middle, showing a peculiar combination of concretionary and laminated structure, unique among our limestones, and preserved by this bed as far as it can be traced. The limestones seen at Little Harbour, Pictou Island, Cariboo and Cape John are of a dark grey colour, caused by carbonaceous matter;

they have a tendency to concretionary structure, and sometimes degenerate into beds of marly clay with large balls of limestone. The limestones appearing at the four last mentioned places are, perhaps, portions of one bed.

The two small beds of coal are similar in appearance to those of the older coal formation. One of them, with its under clay, is included in coarse grey sandstones; the other rests on limestone, and is succeeded by some grey clay and dark shale.

The conglomerates cannot be distinguished from those of the lower carboniferous series. Both are of reddish-brown colours, and composed of fragments of various hard rocks, usually united by a calcareous cement.

It appears from the foregoing descriptions that, in lithological character, the newer coal formation of Pictou strongly resembles the lower carboniferous series; the chief differences being that, in the former, the beds of grey sandstone are of greater comparative thickness, and that, in the latter, there are great beds of gypsum and of limestone with marine shells. Our coal measures may thus, in one point of view, be regarded as a subordinate group, included in a great thickness of sandstones and shales, mostly of red colours.

The sections which I have described are included in a district extending about fifty miles along the shores of the Gulf of St. Lawrence, from Merigomish to Wallace; forming, I believe, the largest continuous tract of rocks of the newer coal formation in Nova Scotia. Along the coast, between these extreme points, the strata are arranged in an undulatory manner, so that the beds seen at Little Harbour probably re-appear at Cariboo, Cape John, and Tatmagouche. Notwithstanding these undulations, however, the general strike of the formation nearly corresponds with the general direction of the coast. This arrangement is due to the circumstance that the great anticlinal line of the Cobequid Hills, instead of being continued to the shores of the Gulf of St. Lawrence, turns to the southward, and appears to be continued by a group of hills extending across the Pictou coal formation trough, and greatly complicating its arrangement. This group, however, being composed of stratified rocks of the older and newer coal formation, must have owed its elevation to disturbances much more recent than those which determined the main direction of the Cobequid Hills, and that of the great anticlinal line, southward of the Pictou coal field.

The greater part of the rocks composing the newer coal formation of Pictou, were formerly confounded, under the name of New Red Sandstone, with a part of the gypsiferous series, and with a deposit of non-fossiliferous red sandstones skirting the shores of the Bay of Fundy, and unconformably superimposed on the older carboniferous strata. I have no doubt, however, that in other parts of Nova Scotia the newer coal formation will be found to be a well-marked carboniferous group. To facilitate comparison with the equivalent rocks of this and other countries, I annex the following synopsis of our Carboniferous series.

Synopsis of the Carboniferous Rocks of Pictou.

1. NEWER COAL FORMATION. — The prevailing rocks are alternations of reddish and grey sandstones and shales, with some coarse conglomerates, especially in the lower part. Subordinate to these, are dark grey concretionary limestone, thin beds of coarse sandy limestone, two thin beds of coal and one of gypsum. Thickness, 5000 feet or more.

FOSSILS. — *Coniferous wood, Calamites, ferns, &c., Ganoid fish, tracks of land animals.*

2. OLDER COAL FORMATION. — The prevailing rocks are dark shales and clays, grey and brown sandstones; and subordinate to these are coal, ironstone, dark limestone. Thickness, 5000 feet.

FOSSILS. — *Ferns, Stigmaria, Calamites, Lepidodendra, &c., Cypris.*

3. MOUNTAIN LIMESTONE, OR GYPSIFEROUS FORMATION. — The prevailing rocks are reddish sandstones, shales, and clays, with some grey beds; conglomerates, especially in lower part; and subordinate to these, thick beds of limestone, thick beds of gypsum with anhydrite. Thickness, 6000 feet or more.

FOSSILS. — *Calamites, fragments of carbonized plants. Producta, Terebratula, Encrinites, Madreporas, &c.*

Small quantities of copper ores are found in the sandstones of the gypsiferous and newer coal formations, especially in the latter. Salt springs rise from the older coal and gypsiferous formations in a few places. Veins of hematitic iron ore occur in the gypsiferous rocks of the East River. The strata of the two older members of the carboniferous system are more disturbed and hardened than the newer series, and contain interstratified and intrusive traps, which appear in no part of the newer coal formation, except the conglomerate at its base.

APPENDIX. — *On the Junction of the Carboniferous and Silurian System at Maccara's Brook.*

SILURIAN and LOWER CARBONIFEROUS ROCKS as seen in the COAST SECTION at MACCARA'S BROOK.



3. Sandstone and shale of a red and grey colour.

2. Conglomerate.

1. Hard shales and impure limestone (Silurian) of a dark grey colour.
Fossil shells.

IN my notes on the lower carboniferous rocks, I described this place; but from want of time, and owing to the state of the tide, when I examined it last summer, I was unable to ascertain the exact nature of the junction of the two formations. Having re-examined the section under more favourable circumstances, I have been enabled to observe distinctly the unconformable superposition of the carboniferous system on the Silurian rocks. As I formerly noticed, the gypsiferous system at this place, in consequence of the absence of gypsum, and the presence of great beds of hornblende trap, presents a very unusual appearance, and could

scarcely be recognised, were it not for the presence of limestone with its characteristic fossils. Of the beds of trap there are four, one of them about 200 feet thick ; and that they are true beds which have been poured out over the bottom of an ancient sea is proved, not only by their regular interstratification among aqueous deposits, and by the earthy texture and amygdaloidal structure of their upper parts, but by the quantity of trap fragments included in the conglomerates which alternate with them. The lower part of one of these beds of conglomerates is, by the admixture of these fragments, converted into a kind of tufa. One of the beds of trap forms the bottom of the carboniferous series, and rests on the edges of hard shales and thin bedded limestones, filled with Silurian fossils. The edges of the Silurian rocks are slightly altered at the point of contact.

These rocks being on the margin of the great line of ancient disturbed strata, which extend from Cape St. George along the southern edge of the Pictou coal trough, have been subjected to more than one igneous convulsion. A few miles further along the shore, the same beds of conglomerate and sandstone, with interstratified amygdaloid, are seen in a vertical position, with their sandstones changed into quartz rock and jasper. This is, apparently, in consequence of the eruption of the crystalline greenstone and other igneous rocks which appear in their neighbourhood, and we are thus informed that the igneous action along the above-named anticlinal line, which continued to the close of the carboniferous period, was exerted also at the commencement of that period, and no doubt influenced the deposition of its strata in a manner as yet very imperfectly understood.

2. GEOLOGICAL FEATURES *of the Country round the MINES of the TAURUS in the Pashalic of DIARBEKR described from Observations made in the Year 1843.* By WARINGTON W. SMYTH, Esq., B.A., F.G.S.

IN that part of Asiatic Turkey, where the provinces of Anatolia, Armenia, Kurdistan, and Mesopotamia unite, the chain of the Taurus is bounded on the one side by the Euphrates and on the other by the Tigris, and this district, being now out of the way of the main roads of commerce, has until within a few years been almost entirely neglected.

The interest, however, attached to these regions in the present precarious state of the Ottoman empire, and the difficulty of obtaining information concerning them, will excuse the imperfect condition of the sketch now offered of the geographical and geological configuration of the country ; but I have to regret that my absence during some years from England prevented my being ac-

quainted with the valuable information to be obtained from the published routes of Messrs. Brant and Ainsworth.*

The line of road which I took enabled me to complete the section of the country in a direct line from the Euphrates to the town of Sivas, and a stay of some weeks put it in my power to obtain some interesting details concerning the important mines of copper at Arghaneh Maden, and of silver at Kebban Maden, as well as others more or less neglected, which lie in various parts of Armenia and the N.E. of Asia Minor.

The great mountain chain called the Taurus by the ancients, runs from the province of Cilicia (now *Adana*) in a north-easterly direction, and often forms large irregular elevated groups; on the eastern side of the Euphrates it spreads in various directions around the great lake of Van, and merges into the high land of northern Kurdistan and the volcanic plateaux of Armenia. At the point where the Euphrates cuts through the Taurus the chain appears to consist of one main ridge, and this afterwards branches off into elevated tracts of very irregular form, one portion extending eastward from the river, and another commencing considerably to the west of it and stretching away towards the north.†

The division of the Taurus with which we have to deal, is separated into two parts by the valley of Kharput, the waters of which flow to the north-east and join the eastern Euphrates. The first of these two portions, in which the river Tigris takes its rise, contains the most elevated points, varying from 6000 to 8000 feet above the sea, and then, proceeding towards the north-east, it joins another range called the Darkush Dag (Niphates) some of whose peaks are estimated at from 8000 to 10,000 feet high.

The second portion from Kharput to the Euphrates does not attain an elevation of more than 5000 feet, and on the north sinks gradually towards the valley of the Murad Tchai.

The eastern or main ridge, whose breadth between Arghaneh and Kharput may be estimated at nearly 50 English miles, presents us with a series of limestones and marly slates belonging to the cretaceous period, and resembling the formations of various countries bordering on the Mediterranean.

¶ The higher portions generally consist of calcareous strata, abounding in nummulites; whilst the marls, which for the most part occupy a lower position, are highly metamorphic, being changed in colour and frequently hardened to the consistency of silicious slate. Below both, although sometimes occurring in dykes high up the mountain sides, appear rocks of diallage and actinolite in great variety.

To the west of Kharput, the mountains exhibit a different cha-

* See "Journal of Royal Geographical Society" for 1841.

† The lesser ridge of the Karajah Dag (Masius) which strikes off from hence to the south-east, should not be considered, as it is represented on the maps, as a branch of the Taurus, being almost wholly unconnected with the greater range, and composed of rocks not seen again nearer than forty miles to the westward.

racter. Their chief mass is composed of limestones and slates of an older period; the limestones of a darker colour than that around Arghaneh; the slate chiefly talcose, and connected with the mica-slates and other primary rocks, described by Russegger as forming the nucleus of the Taurus in the district of Adana. The eruptive rocks, occurring in juxtaposition with these, are syenite, diallage rock, basalt, similar to that of the plateau of Diarbekr, and lastly, at Kebban Maden, a felspar-porphyry.

Such are the rocks presented in this transverse section of the chain, and the determining of their boundaries is much assisted by the nature of the ground; for the Taurus is, in this part, so totally bare, that it seldom happens that its geological features are obscured by trees, grass, or even vegetable earth. That forests, however, have once existed, and that at no very distant period, is evident from the oak brushwood which is occasionally met with; though the inhabitants, in order to supply the furnaces, cut away with unsparing vigour the shoots as fast as they spring up.

The city of Diarbekr is built on an extensive plain, covered with rough fragments of basalt, resting upon more compact masses of the same rock; and through these the river Tigris has cut for itself a valley about a hundred feet in depth. On the south of the city, the hills of the Karajah Dag exhibit varieties of the same rock, which is sometimes amygdaloidal, sometimes scoriaceous. These hills often rise up in strongly marked cones, which bear exactly the type of the ancient secondary cones of Etna; and are covered by various accumulations, and in some cases overgrown with trees. On the south-west, this igneous formation extends beyond the town of Siverék, a distance of sixty miles from the Tigris; and in approaching the mountains to the north-west, we find the same series continued for twenty miles. At Arghaneh the southern outposts of the Taurus present their most remarkable features. The celebrated Armenian monastery of this name is built on the summit of a calcareous mountain, which attains a height of 2000 feet above the plain, or 4000 feet above the sea, and is conspicuous from a great distance, owing to its two sharp peaks. Hence we find the place designated in some old maps as *Arx bicornis*. The chief component rock of this and the neighbouring elevations, on the north and east, is a compact light coloured limestone, generally abounding in nummulites, and sometimes exhibiting fragments of pecten and ostrea. Against its flanks, on the east and west, rest beds of porphyritic conglomerate, of which the rolled fragments consist chiefly of greenstones with imbedded large crystals of hornblende. The stratification of the limestone is not very distinct at this spot; but, on the road to the north-west, the beds become remarkable, being exhibited in long denuded parallel lines, generally tilted from the southward. The limestone is accompanied by slates of a highly metamorphic character: they are black, grey, ferruginous, or green in colour; and from beneath them there appears a greenstone porphyry, which,

in some parts having its hornblende replaced by diallage, or its felspar paste by a magnesian one, passes gradually into diallage rock and serpentine, and rises in dykes, or is laid bare in the bottom of deep valleys, at several points between this and a Koord village about five miles to the north-east.

The elevated peninsula formed by the Tigris, which is crossed by the road to Arghaneh Maden, is composed almost entirely of ophiolite, or of a variety of serpentine and diallage rock. These are seen immediately on the western side of the river, which is here crossed by a stone bridge. The colour of the rocks is commonly bottle green ; but hardly a square yard of it is homogeneous, so frequent are the changes in the material. The cracks and fissures are filled with precious serpentine, with asbestos, and other minerals, chiefly of silicates of magnesia. The greater portion of the rock, however, is characterised by interspersed foliated crystals of diallage, sometimes as large as the palm of the hand, which reflects so brightly the sun's rays as to be generally taken by the natives for a species of silver. About a mile further to the

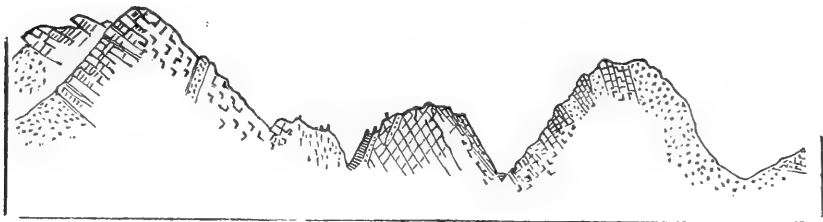


north, at the opening of a valley which runs up from the Tigris in the direction of Maden, are found some very singular conical mounds and hills, which render probable the eruptive origin of the serpentines. Their summits are formed by a crest of tilted strata of limestone or shale, supported by a mass of serpentine or diallage rock, which has been much decomposed by exposure, and is even sometimes so much worn that the cap of harder stone projects from its base, as if nicely balanced upon it by art.

On the road to the mines, are passed strata of finely laminated shales, which are, here and there, interrupted by dykes or masses of diallage rock, and frequently become allied to jasper.

The serpentine is laid bare at Arghaneh Maden, in the valley of

MINING DISTRICT OF ARGHANEH-MADEN.



The dotted parts in this diagram represent diallage rock, the crossed lines an irregular mass of sulphuret of iron and copper in which the mines are situated, and the remainder of the marks, limestones, and metamorphic slates of various periods.

the Tigris, and in the ravine formed by a rivulet which pours in its tribute close below the town. The rock is generally full of diallage, and contains the other magnesian minerals before described. From its being intersected in all directions by fissures

and joints of separation, it is not applicable to the purposes of building. Between the rivulet and the Tigris, or to the north of the main portion of the town, the serpentine does not rise high above the level of the valley, but, at a few feet above it, is capped by slates and marls, partly crumbling and partly jaspery; the former being of a dark grey colour, and the latter having a brownish red tint.

The steep south side of the ravine is of a different character. In contact with the serpentine appears a ferruginous breccia, consisting of angular fragments of ochreous marls and sandstone, and, more rarely, pieces of porphyry, cemented together by hydrous oxide of iron, and forming a bed of considerable thickness. This is used as a building material, being easily worked, and tolerably durable, but its dull rusty appearance, combined with the total absence of herbage and the strangely coloured sterile slopes of the surrounding mountains, give the place a character of unequalled dreariness.

Higher on the mountain there rise up, from beneath beds of marl, rugged masses of diallage rock, and these extend in the form of a powerful dyke over the shoulder of the height towards the south. In the portions where it is friable this dyke is deeply furrowed by the rains and the tracks of the animals, which are constantly passing and repassing with charcoal for the furnaces. Its position in this form and at this elevation is important, as tending to prove that the limestone was not deposited upon it, as might have been argued, from seeing the diallage rock constantly laid bare in the deep valleys, where the superincumbent limestones and marls have been removed. On the summit of the mountain, to the west of the town, marls and limestone are again found; and the limestone incloses numerous nodules of serpentine projecting from the weathered face of the rock, and thus exhibiting a greater degree of hardness.

It is to its copper mines that Arghaneh Maden owes all its importance. The breccia before mentioned appears to constitute the outer wall of the cupriferous mass. This mass, though it continues in depth to the level of the waters of the Tigris, has not hitherto been opened anywhere except on the surface of the mountain above the town.

It appears to be but one huge lump of ore, consisting of the double sulphurets of copper and iron, planted amid the serpentine, or perhaps between it and the marls. In the mines which I entered, not the slightest character of a vein or bed was to be seen, but floor, and roof, and walls consisted entirely of solid pyrites, diversified only by stalactitic coatings of blue and green vitriol. This extended to a depth of 10 or 12 fathoms; but the additional 20 or 30 feet which had been excavated, were filled with water, which had for upwards of a year kept the works almost at a standstill. It is only by waiting patiently until the month of July or August, that access is gained to the lower parts of the mine. The accumulated rains of the winter and spring at that time gradually

find their way out through crevices into the valley below, and leave the mines dry for a few weeks.

The shafts, which belong to different individuals, are scattered irregularly over a part of the mountain, which is almost level, and is about fifty fathoms in diameter; and since in all of these shafts the same appearances are presented, we may be justified in considering the ore as forming rather an insulated mass, than as belonging either to a bed or lode.

The pyrites varies so much in quality, that a large proportion is left untouched by the miners, not repaying them for working; the generality of ore contains from 10 to 12 per cent of copper, whilst the better sorts rise to 20 or 24 per cent; and occasionally a little vitreous copper, or pure sulphuret occurs, when the per centage is much higher. The boundary of this mass of ore is hitherto unexplored, but judging, as before, from the area occupied by the mine entrances, it cannot be less than fifty fathoms in diameter; and since the ore is again met with, and even of better quality, in an adit now driving from the valley of the Tigris, it appears that it continues also thus far in depth, perhaps 50 or 60 fathoms.

The workings are conducted on a miserable plan, adopted indeed in all the Turkish mines, but which will soon bring the present undertaking to an end, and entail difficulty on future enterprise. A shaft is sunk from the surface at an angle of 45° with the horizon; and it is secured, somewhat insufficiently, by timbering, and provided with rough wooden steps for ingress and egress. As soon as a good portion of the ore is thus reached, the miners work off in different directions, digging out in the most irregular manner only that which pays them best, and leaving the rest to stand or break down as accident shall determine.

The road to Kharput or Palu ascends steeply, to the west of Maden, across a ridge through which the Tigris rushes, in a narrow glen many hundred feet below. The first part of the acclivity, after leaving the diallage rocks, is composed of very thin marly slates, easily separating into rhomboidal fragments. Then follow various amygdaloidal rocks, exhibiting spicular crystals of felspar in a paste, composed partly of felspar, and partly of carbonate of lime, — a continuation, in short, of the metamorphic rocks which generally accompany the near approach of the serpentines to the secondary limestones and shales. The crest of the mountain is composed of powerful banks of limestone, tilted towards the north-east, to which succeeds, about a hundred feet lower down, serving as a base to the rugged cliffs presented by the stratified rocks, the hornblende-porphry which we before had in conjunction with the serpentines. After this steep descent, the road ascends by a very gentle rise the course of a stream to the west, in a valley bounded sometimes by mountains whose lower parts are porphyritic, and sometimes by limestone hills inclining to the north-west. It then crosses a water-shed, and, after passing a third isolated khan, enters a perfectly level plain of about six miles in length and two in breadth, through which the

main feeder of the Tigris flows from some peaks on the south-west. Judging from the quantity of snow which still lay there in the month of June, the elevation of these peaks must be considerable. After ascending from this plain, a narrow and low ridge of limestone strata, inclining to the north-east, separates the waters of the Tigris from those of the Euphrates. On its western side is a lake, the direction of which is nearly east and west, its length being ten or twelve miles, and its breadth three or four; and this lake is said to give off its surplus water to the Euphrates. In the valley, at its eastern end, through which flows a small tributary stream, occur numerous instances of diallage rock, in which the foliated crystals are remarkably large and beautiful. The ascent westwards is again over porphyry and greenstone. The summits of the high ridge we then cross are formed principally of limestone, and the descent to the broad valley which lies on its other side, offers steep slopes, on which are exposed, at intervals only, rocks of actinolitic porphyry and diallage, which appear to be intimately connected with each other.

This fertile valley, through which a stream takes its course to the Murad Tchai, near the town of Palu, is entirely covered by alluvial soil; and being carefully irrigated by the inhabitants of its numerous villages, presents a great contrast to the sterility of the mountains. Its height above the sea, from the observations of Ainsworth and Brant, is about 2500 feet. The hills which project into it towards the town of Kharput consist mainly of marls and sands, much decomposed and deeply furrowed by rains.

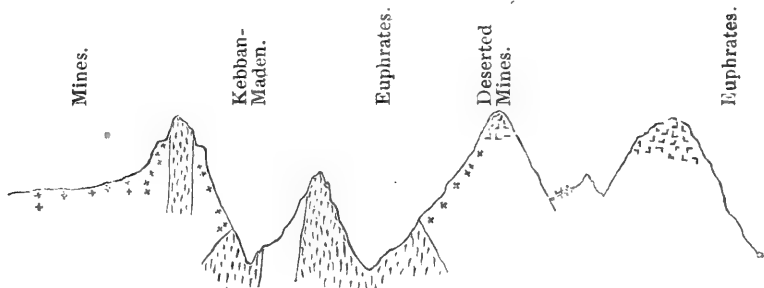
At Kharput, a fine natural section is presented to the steep face of rocks opposed to the east. This lower portion is composed of a greenstone porphyry, disintegrated and rounded by the action of the weather, whilst the upper part consists of thick massive strata of compact limestone, having an inclination to the north-west, of about 30° , and split by numerous fissures at right angles to the plane of inclination. The contact of the two rocks may easily be observed; but the limestone appears to have undergone no change, whilst the porphyry has become so friable that it is generally eaten away by the air and rain to a depth of several feet below the bed of limestone.

To the west of Kharput, the country assumes a very broken aspect, and exhibits confused groups of lower elevations, extending towards the valley of the Murad Tchai, beyond which is now seen a magnificent range of mountains, the Dujik Dag, running about east by north, and west by south, and in the month of June still capped with snow. The hills nearest to Kharput consist of limestone and shale, but about three miles to the north-west appears a grey syenite, with large and well-formed crystals of black hornblende, yielding very readily to the action of the atmosphere. The mounds thus composed open out into a plain which is divided into natural terraces, and which in its geological features presents a repetition of the plateau of Diarbekr on a small scale, the whole surface being strewn with blocks of basalt of every size, which are so

numerous as to render the road very difficult for the horses, and make it necessary for the inhabitants to form huge piles of stones in preparing a small piece of ground for cultivation; though the quality of the black soil, then sparingly occurring, is good enough to repay them for their labour. The low ridge which bounds this plain on the west consists of a grey limestone, associated with thin marls, the strata inclining to the south-east; and on its opposite side, where the road winds among some narrow gullies previous to entering among higher mountains, syenite, diallage rock, and hornblende porphyry are found in close connection with each other.

About eighteen miles west-north-west from Kharput, a group of limestone mountains fills up all the space intervening between this point and the Euphrates to the north and west; and through these a deeply-cut valley runs to the north-west, extending for six or eight miles to the Euphrates, where, for some distance around the point of confluence, are worked the silver mines of Kebban Maden.

MINING DISTRICT OF KEBBAN MADEN.



The dotted parts indicate the presence of felspar porphyry, the small crosses metalliferous threads and nodules; two of the hills are capped with limestone, chiefly of the cretaceous period, and the rest of the diagram represents older limestones and talcose slates.

The mountains around the silver mines exhibit, in general, bare surfaces of grey compact limestone, or of argillaceous and chloritic slates, both of which appear to be without fossils. On both sides of the valley in which the town is situated, rise sharp peaks of a hard felspathic porphyry, containing large crystals of pink common felspar, and sometimes exhibiting a slaty texture, with the crystallised parts so ill defined, that where it occurs in contact with the clay slates, it is difficult to assign to each its proper boundary. This eruptive rock also makes its appearance more frequently in the bottom of the neighbouring valleys; as, for instance, below the furnaces, and at the lower parts of the slopes which border the Euphrates. A sharp ridge of the same rock runs along the back of the east side of the town, and there forms bold precipices facing the river which flows almost beneath. A little further to the north, the porphyry is interrupted by a band of ochreous matter, which, probably before the formation of the

valley of Kebban, communicated with a similar patch on the opposite side, forming a lode or dyke. The surfaces of the hills, as well here as on the opposite side of the Euphrates, are covered with innumerable rubbish heaps, formed in attempts to open mines which have rarely been pushed more than two or three feet into the ground. The mines at present worked (which are three in number) lie beyond the ridge on the west of the town, and are even more miserably directed than those of Arghaneh. The adit mouths are driven through shale and limestone, which, here and there, shows on the surface small strings and lumps of galena; but so irregular and dirty are the works, that little can be seen underground to inform us how the ore occurs. The lower mine exhibited some rich portions of nearly pure argentiferous sulphuret of lead, but it nowhere had the appearance of occurring in veins, and I could not hear of crystallisations or druses. In the upper mine, a large quantity of soft iron ochre, a sort of gossan mingled with threads of gypsum, is excavated as ore, being found to contain, like the galena, from an ounce to an ounce and a half of silver in 100 lbs.

The miners told me that near the junction of two species of rock, whether limestone or shale, or of one of these with porphyry, they find the ore more plentifully disseminated than elsewhere.

Dressing or preparing the ores is not understood, so that all which is not rich enough to go at once to the furnace is wasted.

Between the Euphrates, at Kebban Maden, and the Kizil Irmak, or Halys, at Siwas, extends a broken and neglected high land, in which the traveller meets with no habitations, except in villages fifteen or twenty miles apart, and these are inhabited by koords of a somewhat lawless character.

On leaving the felspar porphyry which is found in peaks, or below the sedimentary rocks at Kebban, a high land of limestone and shales is reached. This high land extends up the course of the Western Euphrates, above Eghin, and towards Kamak, where the limestone forms the sides of a magnificent gorge through which the river flows. Superimposed on the older grey limestone, occur beds of a white calcareous rock of softer character, which mineralogically has a strong resemblance to the *calcaire grossier*, or *Grobkalk* of the Vienna basin, and contains the shells of oysters. About twelve miles from Kebban, the almost level country is strewn with basalt blocks, like those of the plateau of Diarbekr, which continue beyond the village of Ergavan. An hour's distance from hence, a long valley running up towards the north-east, exhibits porphyries frequently trachytic in character, and containing hornblende crystals in a felspar paste; and also banks of a conglomerate, containing fragments of the same porphyry. Then, after passing the water shed, about ten miles before reaching Hakim Khan, rise on the right hand precipitous heights of compact limestone in beds inclining to the west; and in some places porphyry comes up from beneath them. The country on the south-west, towards the Euphrates, is composed of low undulations of sand and marls.

Around Hakim Khan are crumbling marls, in vertical or highly inclined positions, running N. E. and S. W.; above which rise a few remarkable peaks of bare white limestone.

Towards Hassan Tchelebi, on the road side for six miles, diorites and serpentine rocks appear, the heights above which, often wooded, and said to be tenanted by wild goats and deer, are of limestone. These calcareous strata, having a moderate inclination to the westward, continue visible as far as the village last mentioned.

From Hassan Tchelebi, for about twenty miles, the rocks are hidden by vegetable mould and grass; though fragments of porphyry, limestones, and marls are found.

From Alajah Khan, for a distance of four or five miles, diallage rocks, often much discoloured by iron, are found; and after this appears limestone, tilted towards the west, then for some distance before reaching Kangal, and from thence as far as Delikli Tash, the slopes are covered with thin grass.

The chain of the Anti-Taurus (Itschitchehi Dag), attaining an elevation of 5800 feet, runs in a very marked line from W. S. W. to E. N. E. The limestones of which the higher part is formed, rest on serpentine; which appears to have coloured and hardened the beds of shale, near the surface of contact. Immediately on the west, towards which side the beds incline, granular gypsum appears in beds of considerable thickness on both sides of the road; and on this lies salt, the presence of which is betrayed by a lake, whose waters evaporate in summer. Eighteen miles from Delikli Tash is found a quartzose sandstone in strata from 2 to 6 feet thick, inclining gently towards the west, and between this and the deeply cut valley of the Kizil Irmak (Halys), that rock continues without interruption.

The preceding observations collected in the course of a single traverse are not a sufficient foundation on which to base general conclusions as to the constancy of the order in which the rocks occur; but since the mere enumeration of the rocks in geographical order is, in general, but a dry repetition, and, for want of comparison with some known scale, is not easily kept in mind, it may be of advantage to conclude with a sketch of the probable order of the formations above mentioned, which may serve as a guide to future travellers in these districts.

The oldest stratified rocks of the series are unquestionably the limestones and chloritic slates of Kebban Maden, which appear to be in connection with the mica slate, forming the nucleus of the Taurus at Adanah: they overlie a felspar porphyry, which seems to have pierced them in dykes, and near the contact affords ores of argentiferous lead.

The second deposit may be the quartzose sandstone which occurs between the range of Anti-Taurus and Siwas; and this deposit, no doubt, belongs to the system observed by Hamilton near Eregli*, to the south of Kaisariyeh, towards the head of the

* These saliferous deposits are probably more recent than the Scaglia Limestones. W. J. H.

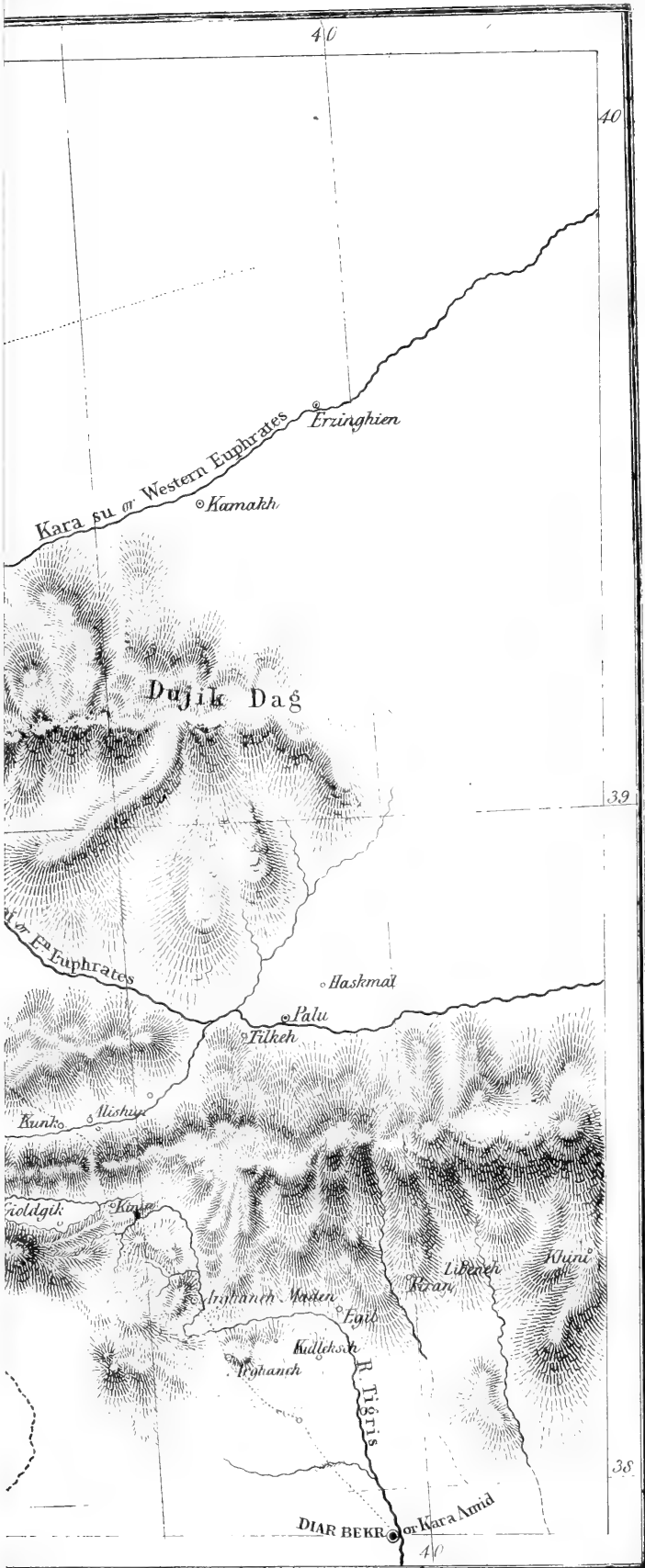
river Melas, and mentioned by him as stretching across from Galatia to Cappadocia. In both places, it is a hard red grit, associated with strata of gypsum, and with red and grey marls; and, in the first case, also with salt.

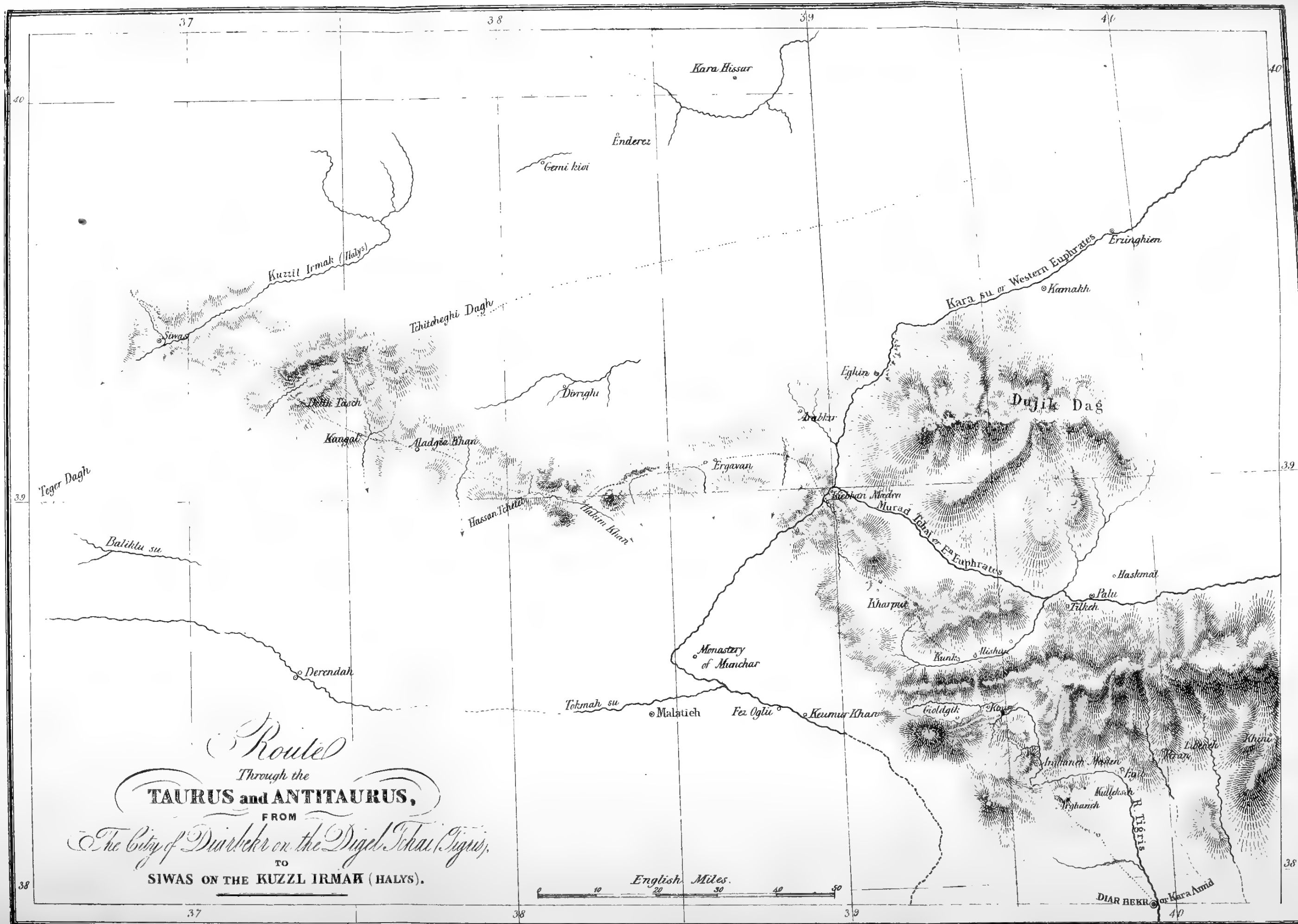
The grey limestone of Arghaneh, Kharput, and the Anti-Taurus, must be referred to the vast calcareous deposit, which, cotemporary with our green sand, occupies an enormous extent of country in Italy, Dalmatia, Albania, Greece, and Syria, on the one hand; and in South France, Spain, the Balearic islands, Sardinia and Sicily on the other, a zone in fact which, from what we find of it again in Egypt and Algiers, appears to encircle the whole Mediterranean. In the Taurus, as in many of those countries, it has been upheaved and pierced by serpentine and diallage rock; and these are the circumstances which in the country I have endeavoured to describe, as well as in the Maremme of Tuscany, at Monte Castelli, Rocca Tederighi, Monte Catini, &c., are associated with the presence of the sulphuret of iron and of the sulphuret and other ores of copper. The lower beds of this limestone, often described under the name of scaglia, are not yet very definitely referred to their place in the geological scale; since they differ much among each other, and are often poor in characteristic fossils; but the upper portion, with its nummulites and the marls associated with it, retains more nearly the same type throughout.

The date of the eruption of the serpentines, which are associated with the cretaceous beds, has been referred by most observers to the tertiary epoch; nor would it appear that those of the Taurus are an exception, since their occurrence in dykes near Arghaneh proves their outburst to have been subsequent to the deposition of the limestones.

I should be inclined to refer to the tertiary period also those limestones which occur on the summit of the mountain west of Arghaneh Maden, and contain imbedded fragments of serpentine; and also those which cap the mountains near the junction of the Murad and Frat; but the line of distinction, from the difficulty of procuring fossils, is not easily drawn. It is however very possible that a more accurate examination may show them to be secondary, and thus prove the outburst of the serpentines to be of remoter date than is generally supposed; or, what is more likely, to have happened not all at once, but at several successive periods.

To the deposition of these calcareous strata have succeeded the further elevation of the chain, and the formation of the existing valleys; phenomena probably contemporaneous with and due to the same cause as those which produced the protrusion of the igneous rock occupying several large tracts in the district under consideration. A further study would doubtless prove these rocks to be connected with the vast series of volcanic rocks, of the same general character, which extend at intervals from the Katake kaumene of Asia Minor to the Taurus, and thence to Mesopotamia on the one hand, and through the north of Syria to Galilee on the other. The protrusion of these rocks is one of the principal agents to which the present configuration of this important tract of country is due.





FEBRUARY 5. 1845.

Thomas Longman, Esq., J. Durance George, Esq., and Captain Barham Livius, were elected Fellows of this Society.

The following communications were read :—

1. *On certain Conditions and Appearances of the STRATA on the COAST of ESSEX near WALTON.* By JOHN BROWN, Esq. of STANWAY.

IN this paper the author first alludes to the information that has been obtained, of late years, respecting changes of elevation that have taken place on many parts of the earth's surface, at comparatively recent geological periods, and refers to the memoir by Mr. Smith, of Jordan Hill, on this subject, as illustrating the nature of the evidence to be sought for. He then endeavours to show that such evidence exists with regard to certain beds containing shells, on the Essex coast, which beds he had been able to examine in consequence of their having been laid bare by an unusually high tide, and by the gradually wasting action of the sea on that coast. He mentions three places in particular, namely, Walton, Clacton, and the valley of the Colne, near Colchester, at each of which he has obtained marine shells from heights to which the sea does not now reach.

At the first of these, Walton Gap, the author describes a bed to which he gives the name of the *till* (assuming it to be identical with the beds so denominated on the banks of the Clyde), composed of clay, with boulders of various kinds and sizes, the surface of which is about 5 or 6 feet above high water mark. The beds containing shells, and supposed to form a raised beach, are seen to rest immediately on this till, or boulder clay, and the shells consist chiefly of those of the common oyster (*Ostrea edulis*) associated with the common muscle (*Mytilus edulis*), and cockle (*Cardium edule*), and other abundant coast shells, such as *Venus decussata*, *Buccinum undatum*, and *Turbo littoreus*. These shells are described as being for the most part quite perfect, and they are generally covered with sand, or with a freshwater bed, about 5 feet thick. The author also alludes to a bed of *Turbo littoreus*, on the spot now occupied by the terrace at Walton.

The next spot described is at Clacton, on the same line of coast, and about eight miles to the south of Walton. A considerable number of marine shells are stated to have been here collected at various heights above high water mark, the highest bed being 8 feet. In this case the marine shells are of the same species as those found on the coast and in the adjacent sea, and they are associated with freshwater species also common in the neighbourhood.

On the western side of the valley of the Colne, and at a distance of about 600 yards from the river, similar beds of shells are de-

scribed as occurring at a height of about 5 feet above high water mark. The shells are numerous and broken, and they are associated with concretions of carbonate of lime. The author considers that this deposit may have been formed at a time when the valley of the Colne was an estuary of the neighbouring sea. The shells are all those of the common recent species found on the coast, but the bed is now ten miles distant from the sea.

The author considers that the perfect state of the shells in these cases precludes the possibility of their having been drifted, and that they therefore afford sufficient proof of the general level of this part of the British coast having undergone a small elevation at a recent geological epoch.

2. *On DYKES of MARBLE and QUARTZ in connection with Plutonic Rock on the UPPER WOLLONDILLY in ARGYLE COUNTY, NEW SOUTH WALES.* By the Rev. W. B. CLARKE, M.A., F.G.S.

THE tract of country described by the author in this memoir is situated not far from Sydney and Port Jackson, the river Wollondilly, whose gorge lays bare the geological structure of the district, taking its rise in latitude $34^{\circ} 26' S.$, longitude $149^{\circ} 23' E.$, and after receiving the waters of several streams running into the Nepean river, and emptying itself into the Ocean considerably to the south of Sydney!

The stratified rocks traversed by the remarkable defiles through which these rivers flow, belong to the sterile upper portions of the carboniferous formation so widely spread in Australia; and these carboniferous rocks are traceable (with occasional interruptions from basaltic dykes) from the district in question to the borders of the Illawarra region, where they present a lofty mural escarpment.

The Wollondilly, however, from its source to its junction with the Uringalla (except near Towrang), is described by the author as running through igneous and metamorphic rocks, which are laid bare over a considerable area between the Cockburndoon, the Derra, and the Uringalla rivers, where recent volcanic outbursts have disturbed the older rocks. The sedimentary rocks wrap round the margin of this area, the beds dipping at a considerable angle.

On the north banks of the river, at a place called Jaoramin, beds of conglomerate are described containing fragments apparently of transition rock; and the author considers, from the condition and appearance of the river banks, and the fact that a wide space, at a considerable height above the water, is covered with the débris of these conglomerates, that a considerable change of level has taken place in the district producing elevation.

Having given a general account of the districts, the author then

proceeds to describe the different plutonic rocks found in it, and states that they consist of syenite, syenitic granite, protogine and porphyritic rocks of various kinds, and of greenstones, basalt, and trachyte, all, with the exception of the three latter, passing by regular gradations from one to another. The syenites are said to resemble those of Skiddaw, and the syenitic granite that of Guernsey, while a protogine is described greatly resembling a beautiful rock of the same kind in St. John's Vale, near Keswick.

At Arthursleigh, the author describes a spot where the face of an exposed cliff exhibits a net-work of quartz veins with dykes of syenitic rock and hornstone; and not far off a dyke of ironstone, and others of basaltic rocks, amongst which are some injected trachytes that have been much used for building purposes.

Having described the position and mineral character of these igneous rocks as they appear *en masse*, the author then proceeds to allude to some singular instances of intrusive dykes of limestone and marble, at a spot known as "Campbells," or "Shepherds," situated on the estate of Arthursleigh just alluded to. These dykes occur in contact with hard large-grained grey syenite, and were seen on the right bank of the river Wollondilly.

In the first instance mentioned, the width of the dyke is stated to be nearly 47 yards, its dip 50° S.W., and its strike S. 22° E. "Alternations of quartz rock and crystalline white and grey marble compose this dyke; innumerable lines and scratches mark the edges and face of the marble; and the quartz has also been subject to a semi-crystalline action, the surface being crumpled or doubled up into parallel anticlinal ridges." There appears to be no line of demarcation traceable between the quartz and marble; and the two together, after descending into the bed of the river, suddenly curve round and re-enter the granite as a second dyke. Traces of green carbonate of copper are found associated with the other minerals of this dyke.

The author considers that the scratches and furrows which he has observed, and other phenomena in the line of dip, could not have been in existence before the formation of the present river channel.

A second dyke is then described in a place where the rocks are thrown into great disorder, and the author details some changes which have produced singular conditions of mineral structure. He also supposes that they exhibit marks of a gradation existing between limestone and quartz. A third dyke of the same character is then mentioned, in which the constituents of the granite are mixed up with the calcareous rock; and the author states that near these dykes the granite assumes a distinct character, a greater proportion of felspar and less mica being present.

At Jaoramin, higher up the river than the spot just alluded to, the structure of the rocks is described as somewhat different, the felspar being less completely mingled with the other minerals, but the rock occasionally passing into porphyry. Where it is not denuded, the rock, however, is here overlaid by a mass of conglom-

merate, from 200 to 300 feet thick, through which the river makes its way. At St. Peters are low hills more decidedly granitic. Near Stuckeys farm are numerous fragments of crystalline rock, the surface of which is much worn, as is the case with other calcareous rocks all over New South Wales. No traces of fossils have been found in these limestones.

The author remarks that the greenstone becomes compact near the marble, and assumes a bottle-green colour, traces of limestone being common in it; whilst on the other hand, the marble near the greenstone is also changed, so that a passage may be traced from one to the other.

The author concludes by referring to other instances in New South Wales, in which similar phenomena have been produced. He mentions one case in lat. $32^{\circ} 6'$ S., and long. about 151° E., where, in the neighbourhood of the river Page, veins of marble intersect a lava-like trap; and another about 16 miles north of Arthursleigh, where a magnificent tunnel in white crystalline marble occurs in the bed of a creek surrounded by basaltic rocks. On a branch of the Abercrombie river, west of the Dividing Range, and about 40 miles south of Bathurst, a similar tunnel of gigantic dimensions, nearly 800 feet long and 80 feet high, also passes through a mass of white crystalline marble at the bottom of a ravine in the middle of a country of volcanic rocks and blocks of snow-white quartz.

The author hopes to be able, at a future time, to describe these examples more fully; he alludes to them now to show that there is reason to believe that these connections of limestone, plutonic rocks, and quartz dykes, are not without their application to a condition of geological phenomena, to the elucidation of which the banks of the Wollondilly have exhibited a clue.

3. *On the ATHERFIELD Section of the LOWER GREENSAND, in the ISLE OF WIGHT.* By W. H. FITTON, Esq., M.D., F.R.S.

[This paper is postponed, not having been received from the author in time for notice in the present number of the Journal.]

II. CATALOGUE

OF

LOWER GREENSAND FOSSILS,

IN THE MUSEUM OF THE GEOLOGICAL SOCIETY,

WITH NOTICES OF SPECIES NEW TO BRITAIN, CONTAINED IN OTHER
COLLECTIONS. BY PROFESSOR EDWARD FORBES, F.R.S.*

(Continued from p. 250.)

MOLLUSCA.

Acephala Palliobranchiata.

99. *Terebratula sella* Sow. M. C. t. 437. f. 1.

Loc. Atherfield, Reigate, Hythe, Faringdon.

NOTE. On the continent this species appears to be confounded with *T. elongata*, from which it is very distinct, and by which it is replaced in the Upper Greensand. In the young state it is broad and depressed, and presents scarcely a trace of the two plications afterwards so prominent.

100. *Terebratula praelonga* Sow. in Fitton, G. T. 2d ser. vol. iv.
t. 14. f. 14.

Loc. Maidstone, Sandgate.

101. *Terebratula.*

Loc. Isle of Wight.

102. *Terebratula sulcata* Parkinson, G. T. 1st ser. v. p. 59.

SYN. *T. multiformis* Roemer.

Loc. Hythe.

- Var. β . *T. parvirostris* Sow. in Fitton, G. T. 2d ser. vol. iv.
t. 14. f. 13.

Loc. Shanklin, Isle of Wight.

103. *Terebratula Gibbsiana* Sow. M. C. t. 537. f. 4.

Loc. Hythe, Atherfield, Peasemarsch.

104. *Terebratula latissima* Sow. M. C. t. 502. f. 1.

Loc. Faringdon.

105. *Terebratula Menardi* Lamarck. (*T. truncata* Sow. M. C. t. 537. f. 3.)

Loc. Faringdon.

106. *Terebratula oblonga* Sow. M. C. t. 535. f. 4—6.

Loc. Atherfield, Hythe, Maidstone.

NOTE. The following recorded British Lower Greensand *Terebratulæ* are not in the Society's collection: — *T. convexa* (Sow. in Fitton, G. T. 2d ser. iv. t. 14. f. 12.); apparently a variety of *sulcata*. *T. depressa* (Sow. M. C. t. 502. f. 2.) *T. elegans* (Sow. in Fitton, t. 14. f. 11.); apparently a variety of *T. Gibbsiana*. *T. Faba* (Sow. in Fitton, t. 14. f. 10.). The original specimen is in the Society's collection, and is from the Upper Greensand of Warminster. It appears to be a young or starved state of *T. biplicata* or some allied species. *T. biplicata* and *T. alata* are included in Lower Greensand lists by mistake. *T. nuciformis* (Sow. M. C. t. 502. f. 3.). *T. quadrata* (Sow. in Fitton, t. 14. f. 9.). *T. tamarindus* (Sow. in Fitton, t. 14. f. 8.).

107. *Lingula truncata*. (Sow. in Fitton, G. T. 2d ser. iv. t. 14. f. 15.)

Loc. Atherfield, Sandgate, Peasemarsch.

NOTE. Specimens of this beautiful species have probably been mistaken for the *Lingula ovalis* of the Min. Conch. t. xix. f. 4., and have led to the insertion of the latter in Lower Greensand lists.

108. *Caprotina Lonsdalii*. (Sow. sp.) Sow. in Fitton, G. T. 2d ser. iv. t. 13. f. 4.

SYN. *Diceras Lonsdalii* Sow.

Loc. Calne.

Gasteropoda.

- 109 ? ? *Pileopsis* (Mantell, G. T. 2d ser. iii. p. 212.) A cast.

Loc. Parham.

110. *Emarginula Neocomiensis* D'Orbigny, T. C. pl. 234. fig. 4—8.

Loc. Atherfield.

111. *Dentalium cylindricum* Sow. M. C. t. 79. f. 2.

Loc. Atherfield.

112. *Natica rotundata* (Turbo sp.) Sow. M. C. t. 433. f. 2.

SYN. *Littorina rotundata* Sow. in Fitton; Morris's Cat.

Ampullaria lævigata Deshayes in Leym. pl. 16. f. 10.

Natica lævigata D'Orbigny. P. F. Ter. Cret. pl. 170. f. 6, 7. (Identified with French specimens.)

Loc. Atherfield, Peasemarsch, Parham, Reigate.

NOTE. *Littorina pungens* of Sowerby, an Upper Greensand fossil, referred to this species by M. D'Orbigny, is distinct.

113. *Natica cornueliana* D'Orbigny, T. C. pl. 170. f. 4, 5.
Loc. Atherfield.

114. *Natica Gaultina* D'Orbigny.

SYN. *Amullaria canaliculata* Mantell. Geol. of Sussex. pl. 19. f. 13.

Natica canaliculata Fitton, G. T. 2d ser. t. iv. pl. 11. f. 12.

Loc. Parham, Hythe, Atherfield.

NOTE. The specific name *canaliculata* having been previously applied by Lamarck to another *Natica*, that of *Gaultina* was substituted by M. D'Orbigny.

115. *Tornatella affinis* Sow. in Fitton, G. T. 2d ser. vol. iv. pl. 18. f. 9.

Loc. Peasemarsch.

116. *Tornatella marginata* (*Auricula* sp.) Deshayes in Leymerie, pl. 16. f. 3.

SYN. *Acteon marginata* D'Orbigny, T. C. pl. 167. f. 89. (Identified by M. D'Orbigny.)

An ovate ventricose shell, with a short spine of six volutions; the upper part of each near the suture is marginated. The whorls are finely striated spirally. On the older shells, these striae usually become obsolete on the middle part of the body whorl. They are very deep on the upper part of the volutions near the suture. The columella is furnished with a single plate.

Loc. Atherfield, Peasemarsch. (Pl. iv. f. 1.)

117. *Tornatella albensis* (*Acteon* sp.) D'Orbigny, T. C. pl. 167. f. 10—12.

Loc. Atherfield. (Identified by M. D'Orbigny.)

118. *Ringinella (Avellana) incrassata* (*Auricula* sp.) Mantell, Geol. Sussex. pl. 19. f. 33. Sow. M. C. t. 163. f. 1—3.

SYN. *Avellana incrassata* D'Orbigny, T. C. pl. 168. f. 13—16.

Loc. Peasemarsch.

119. *Eulima melanoides* Deshayes, in Leym. pl. 16. f. 6. D'Orb. T. C. pl. 155. f. 16.

Loc. Shanklin.

120. *Eulima*. ?

Cast of a large species with slightly rounded whorls.

Loc. Parham Park.

121. *Turritella Dupineana* D'Orb. T. C. pl. 151. f. 1—3. ?

Loc. Atherfield.

122. ? *Turritella granulata* Sow. M. C. t. 565. f. 1. ?

Loc. Ingoldsthorpe, Norfolk. (Impressions.)

123. *Turbo Yonninus* D'Orbigny, T. C. pl. 183. f. 8—10. ?

Loc. Maidstone.

124. ? *Turbo munitus*. Sp. nov. (Pl. iv. fig. 2.)

T. ? testâ conicâ, anfractibus 5, convexis, spiraliter transversèque striatis, superioribus 2-carinatis, ultimo 5-carinato, supernè planato; aperturâ orbiculari angulatâ.

Diam. $1\frac{3}{4}$; alt. $1\frac{7}{12}$ unc.

Shell conic, thick, with very convex whorls, all of which are regularly and finely striated spirally, and crossed by somewhat irregular undulating lines of growth. The ridges between the spiral striæ are alternately larger and smaller. The upper whorls are encircled by two strong keels, and are flattened in the broad space between the uppermost keel and the suture. The body whorl is encircled by five keels, of which the three lowest are close together. Its summit is also flattened. The spaces between the others are hollowed out. The keels are rugged where crossed by furrows of growth.

Loc. Peasemmarsh.

125. *Trochus albensis* D'Orbigny, T. C. pl. 177. f. 1—3. ?

A small, depressed, umbilicated, smooth shell of three or four whorls, the last of which is rounded.

Loc. Peasemmarsh.

126. *Trochus decussatus* (*Littorina* sp.) Deshayes in Leymerie, t. 17. f. 6.

A conical turreted shell with five or six rounded spirally furrowed whorls.

Loc. Maidstone. (The specimen in the collection is $\frac{1}{4}$ of an inch high, and about the same breadth at the base.)

127. *Solarium minimum*. Nov. sp. (Pl. iv. fig. 3.)

S. testâ elevato-conicâ; anfractibus planis, spiraliter sulcatis, at suturis marginatis granulatis; ultimo angulato, marginato, margine crenato; basi convexiusculo, concentricè striato, profundè umbilicato, umbilici margine crenato; aperturâ angulatâ.

Alt. $0\frac{1}{10}$ unc.; lat. idem.

A very minute but very distinct species. It is conical, with an acute spire of five or six flat whorls, which are marked by six to seven spiral furrows. At the margin of the suture the furrows are crenated, and round the angled base of the last whorls runs a crenated band. The base itself is convex and finely striated

concentrically. The umbilicus is very deep and has a crenated margin.

Loc. Atherfield.

128. ? *Solarium Benstedii*. Nov. sp.

S? testâ conicâ, anfractibus 6, planis, transversè sulcatis, ultimo marginato.

Alt. $0\frac{3}{12}$ unc.

Too imperfect for figuring, but very distinct. It resembles in form the *Trochus striatulus* of Deshayes (Leymerie, t. 17. f. 1.), but differs in being transversely instead of spirally striated. I have not seen the base.

Loc. Maidstone.

129. *Pleurotomaria gigantea* Sow. in Fitton, G. T. 2d ser. vol. iv. t. 14. f. 16.

Loc. Boughton.

130. *Pleurotomaria Anstedii*. Sp. nov. (pl. v. fig. 1.)

P. testâ subdepresso-conicâ, anfractibus 6, convexis, spiraliter striatis, striis inæqualibus, transversè substriatis, infernè ad suturam fortè marginatis; sulco centrali crenato; basi excavato, umbilicato. (Nucleo lævi).

Diam. 3; alt. $1\frac{3}{4}$ unc.

Shell conic, thick, the spire somewhat depressed and very obtuse. The whorls are spirally striated; the distances between the striæ are unequal. They are convex, slightly keeled in the centre, where runs the crenated furrow, and strongly margined at the suture below. The striæ are crossed by lines of growth of varying strength, and give in places a decussated appearance to the surface. The upper whorls are slightly undulated. The base is not perfect in any of the specimens, but appears to have been concentrically striated and umbilicated. The upper part of the last whorl appears to have been strongly undulated at intervals. This fine species is allied to some of the French *neocomian* forms. The cast is smooth.

Loc. (Fuller's earth pits, Nutfield, near Reigate.)

131. ? *Pleurotomaria*?

The cast of a very conical *Pleurotomaria* or *Trochus* presenting about nine flattened whorls.

Loc. Sandgate.

132. *Scalaria*? (Plate iv. fig. 4.)

Whorls longitudinally ribbed, ribs arcuated and interrupted on the body whorl by an obsolete keel surrounding the base. A fragment of a shell nearly allied to *Scalaria canaliculata* D'Or-

bigny, T. C. pl. 154. f. 1. A figure of our specimen is given to draw attention to a remarkable species.

Loc. Atherfield.

133. *Rostellaria Robinaldina* D'Orbigny.

Loc. Atherfield, Shanklin, Peasemars, Pulborough.

This is the *Rostellaria Parkinsoni* of British Lower Greensand lists. Under the name of *Parkinsoni* many species have been confounded. 1st. The Blackdown species of which a good figure is given in Dr. Fitton's Memoir, and which may be regarded as the original species of Parkinson, the uppermost of the two figures numbered 3 in plate 558 of the Mineral Conchology being taken as representing the type. In the *R. Robinaldina* the keel of the labial wing is continued over the body whorl, and the ribs on that whorl are very short. In the Upper Greensand or Blackdown species the body whorl is not carinated and the ribs are long. 2d. The London clay species now called *Rostellaria Sowerbii*. 3d. The chalk marl species figured and named *Rostellaria Parkinsoni* by Dr. Mantell in his Geology of Sussex, who however gives the same name to the Lower Greensand species. The chalk marl form may be identical with, 4th, the species from the Gault called *Rostellaria marginata* in Dr. Fitton's Memoir, and which is the *Rostellaria Parkinsoni* of D'Orbigny. It has two keels on the body whorl. 5th. The species before us, for which D'Orbigny's name had best be retained.

134. *Rostellaria glabra*. Sp. nov. (pl. iv. fig. 5.)

Testâ elongatâ, anfractibus 9, superioribus obliquè costatis spiraliter striatisque, striis ad suturam profundioribus, ultimo anfractu glabro, labro expanso, aliformi, truncato.

Lon. $2\frac{1}{2}$; lat. $1\frac{1}{2}$ unc.

Shell elongated, whorls rather convex, those of the spire are striated spirally, the striae near the suture being so deep as to give them a marginated aspect, and crossed by oblong slender ribs which are much less numerous than in the last species. The body whorl is gently rounded and nearly smooth, or with a few spiral striae only near the suture. The whorl next above it is also free from transverse ribs. The lip is very large and expanded. It is produced above into a long slender linear spur, which if attached to the spire would have converted the shell into a *Pterocera*. In front the lip has two other diverging spurs of a lanceolate form. The canal is long and very slender.

Loc. Atherfield.

135. *Pterocera retusa* (*Rostellaria* sp.) Sow. in Fitton, G. T. 2d ser. vol. iv. pl. 18. f. 22.

SYN. *Rostellaria bicarinata* Deshayes? (*Pterocera bicarinata* D'Orbigny.)

Loc. Atherfield.

NOTE. *Pterocera moreausiana* D'Orbigny, T. C. pl. 211. f. 1—2. comes very near this species.

136. *Pterocera Fittoni*. Sp. nov. (pl. iv. f. 6.)

P. testâ brevi, crassâ, anfractibus 6, spiraliter striatis, superioribus 3-carinatis, ultimo 8-carinatis, carinis duabus majoribus, crenulatis, labro quadridigitato, digitis linearibus, arcuatis.

Lon. $1\frac{8}{12}$ unc. Lat. ?

Body of the shell ovate, ventricose with a spire of 5 whorls, all finely striated and ribbed spirally. The ribs on the upper whorls are few and nearly equal; those on the body whorl are numerous and of various dimensions; two corresponding to the anterior digitations of the lip are very strong, prominent, and crenated. A strong rib also runs between them. The lip is much dilated and is furnished with 4 digitations, the two anterior free, the two posterior attached, that above to the spire, and the lower one to the canal. The superior digitation is very long, linear, and curved, and exceeds the spire by half its length. The canal is also linear and curved. In all the specimens the anterior digitations are imperfect.

Loc. Atherfield.

NOTE. This species is nearly allied to *Pterocera retusa* and *Pterocera moreausiana*. From the former it is distinguished by the crenated keels of the body whorl, their number and size; from the latter by the same characters, and by the long linear superior digitation.

137. *Cerithium Neocomiense*. (Pl. iv. fig. 8.) *Cerithium Neocomiense* and *C. Beaudouini* D'Orbigny.

C. testâ conicâ, turrîtâ, anfractibus 9—11, convexis, carinatis, transversè undulato-striatis, carinis lævibus.

Lon. $\frac{8}{12}$; lat. $0\frac{5}{24}$ unc.

Shell turreted, lanceolate, whorls carinated, the keels sharp and regular, usually only one on the upper whorls, and two or three on the lowermost, never crenated, crossed by undulating striæ of growth, and sometimes obscure spiral striæ. Canal very short. A very beautiful species, variable in proportions and degree of carination. The British specimens are usually intermediate between the variety figured by D'Orbigny under the name of *Cerithium Neocomiense* (T. C. pl. 232. fig. 8—9.), and that named by him *Cerithium Beaudouini*, and figured under the name of *Rostellaria pyramidalis* in his plate 206. fig. 7—8. Judging from the figure, his *Cerithium tectum*, a gault species (T. C. pl. 230. f. 4—6.) does not appear to be more than a variety.

Loc. Atherfield. (In the Cracker bed.)

138. *Cerithium turriculatum*. Sp. nov. (Pl. iv. fig. 7 a.)

C. testâ conicâ, turritâ, anfractibus 9—11, convexis, carinatis, transversè obsoletè striatis, carinis nodulosis.

Lon. $0\frac{1}{2}$; lat. ult. anf. $0\frac{5}{4}$ unc.

Var. β . angustivè. (Pl. iv. fig. 7 b.)

Shell turreted, lanceolate, with convex whorls which are surrounded by a spiral keel often doubled on the body whorl. This keel is not so prominent as in the last species, and is nodulated. The whorls are margined at the suture. They are crossed by obscure lines of growth. There are two varieties, the one branch broader than the other.

Loc. Atherfield. (Common in the Cracker bed.)

139. *Cerithium attenuatum*. Sp. nov. (Pl. iv. fig. 11.)

C. testâ angustissimâ, elongatâ, anfractibus numerosis, carinatis spiraliter costatisque, costis omnibus nodulosis.

Lon. $0\frac{1}{2}$; lat. $0\frac{3}{4}$ unc.

A very distinct species, extremely friable and seldom found at all approaching to perfect. It is extremely slender, with many whorls which are spirally ribbed; the ribs are from 5 to 7 on each whorl, all nodulated, and the centre one forming a sharp and prominent keel.

Loc. Atherfield.

140. *Cerithium Phillipsii* Leymerie, pl. 17. fig. 10.?

Nearly resembling the recent *Cerithium Lima*. The whorls are encircled by 3, 4 or 5 granulated ribs, and are crossed at intervals by varices. (Plate iv. fig. 12.)

Loc. Atherfield.

141. *Cerithium Clementinum* D'Orbigny, T. C. pl. 228. f. 1.??

C. testâ turritâ, anfractibus convexiusculis, spiraliter striatis, longitudinaliter costatis, costis granulosis; suturâ impressâ.

Differs from the last in the flatness and narrowness of the whorls. (Plate iv. fig. 9.)

Loc. Atherfield.

142. *Cerithium Lallierianum* D'Orbigny, T. C. pl. 229. f. 7, 8.

A short, ventricose, 7-whorled species, spirally striated and strongly ribbed longitudinally, the ribs ceasing half way down on the body whorl. It agrees well with D'Orbigny's figure. His species is however from the Gault. It has much the aspect of a *Nassa*. (Pl. iv. fig. 10.)

Loc. Atherfield. (In the Cracker beds.)

NOTE. Figures are given of all the Lower Greensand *Cerithia*, on account of the difficulty in distinguishing the species from description alone. It is probable that several other species besides those enumerated will yet be found, especially in the Cracker beds.

Cephalopoda.

143. *Belemnites lanceolatus* Sow. M. C. t. 600. f. 8, 9.?

Loc. Boughton, Atherfield, Maidstone. The specimens are very imperfect.

144. *Nautilus radiatus* Sow. M. C. t. 356.

Var. β . *Nautilus neocomiensis* D'Orbigny, T. C. pl. 11.

Loc. Sandgate, Atherfield, Peasemars, Hythe.

NOTE. The form β scarcely deserves the distinction of a constant variety. The two forms occur together and pass into each other. Specimens occur occasionally closely resembling, if not identical with *Nautilus pseudo-elegans* D'Orbigny, T. C. pl. 8. and 9. Röemer considers *Nautilus radiatus* itself a variety of *Nautilus elegans*. They appear to me to be truly distinct and representatives of each other in time.

The *Nautilus* from the Lower Greensand of Sandgate, recorded as *Nautilus simplex*, appears to have been a bad specimen of the *Nautilus radiatus*.

The young of the *Nautilus radiatus* is the *Nautilus inæqualis* of the Mineral Conchology. Pl. 40. lower figures.

145. *Nautilus undulatus* Sow. M. C. t. 40. upper figure.

Loc. Red Hill, near Reigate (where this fine species is frequent).

146. *Nautilus plicatus* Sow. in Fitton, G. T. 2d ser. vol. iv. (woodcut.) p. 129.

SYN. *Nautilus Requienianus* D'Orbigny, T. C. pl. 10.

Loc. Court-at-Street.

147. *Ammonites Nutfieldiensis* Sow. M. C. t. 305.

Var. β . *Simsii*. Inner volutions more exposed, outer whorl narrower, ribs strong and acute.

Loc. Maidstone. β . at Hythe (perhaps a distinct species).

148. *Ammonites furcatus* Sow. in Fitton, G. T. 2d ser. vol. iv. pl. 14. f. 17.

Loc. Hythe, Atherfield.

149. *Ammonites Deshayesii* Leymerie, Mem. Geol. Soc. Fr. vol. v. t. 17. f. 17.

Loc. Atherfield, Hythe. Identified with French specimens. (pl. v. fig. 2.)

150. *Ammonites mammillaris* Schlotteim (D'Orbigny, Morris's Cat.)

SYN. *Ammonites monile* Sow. M. C. t. 117.

Loc. The specimen in the collection is marked "Lower Greensand," but no locality is given.

151. *Ammonites Martinii* D'Orbigny, T. C. pl. 58. f. 7—10.

Loc. Atherfield, frequent in the upper beds, and growing to a considerable size. The figure (pl. v. fig. 3.) represents a young specimen from that locality. Identified with French specimens.

152. *Ammonites Cornuelianus* D'Orbigny, T. C. pl. 112. f. 1, 2.

Loc. Hythe.

153. *Ammonites Hambrovi*. Sp. nov. Pl. v. f. 4.

A. testâ discoideâ, inflatâ, profundè umbilicatâ, transversè costatâ, costis numerosis, crassis, rotundatis, inæqualibus, tuberculis magnis, latis, prominentibus, marginis interni anfractuum plerumque orientibus; dorso lato, rotundato; aperturâ dilatatâ, latâ, reniformi, lateraliter uni-tuberculatâ; septis lateraliter bilobatis, lobis lateralibus obscuris, lobo dorsali maximo, sellâ laterali superiori latissimâ.

Diam. $2\frac{3}{4}$; crass. $1\frac{3}{4}$; lat. apert. $1\frac{1}{2}$ unc.

Shell ventricose, suborbicular, deeply umbilicated, the umbilicus rather narrow, exposing about one-third of three inner volutions, very steep at their sides. Whorls with large broad and strong tubercles, variable in relative size, studding the margins of the umbilicus, and each giving rise to two, or, in some cases, three strong rounded ribs, which run over the back without interruption. A similar rib is seen between each pair of tubercles. The last whorl suddenly increases in breadth. The back is very slightly depressed. The mouth is broad and reniform, and is angled on each side by a single tubercle. The septa of the chambers are well seen on most of the specimens from Atherfield. They consist of a dorsal lobe, and two or sometimes three lateral lobes. The dorsal lobe is largely developed, and is composed of a broad quadrate base with pinnated sides, and two long pinnated terminal branches. The lateral lobes are but slightly developed and very distant. The superior lateral saddle is very broad, large, and rounded, and divided at its margin by crenated lobations. The dorsal saddle is small and ovate. The other lateral saddles are small and shallow.

This species belongs to M. D'Orbigny's group of *Anguli-costati*. It is frequent in the Cracker bed at Atherfield. It was sent to France and returned as *Ammonites Cornuelianus*. It differs however so materially from M. D'Orbigny's figures and description of that species, and from British specimens, which exactly agree with those figures and that description, that I do not hesitate to regard it as distinct. It may be distinguished from *A. Cornuelianus* by the following characters: 1st, peculiarity of form dependent on the rapid increase of the volutions; 2d, position of the large tubercles and absence of the second series of tubercles, which, together, give the aperture of *A. Cornuelianus* a quadrangular form; 3d, form of the chambers, the dorsal lobe in *A. Cornuelianus* being much broader and its branches more

digitated, and the superior lateral lobe fully developed and much divided.

Loc. Atherfield.

154. *Ammonites multiplicatus* Röemer, Cret. Geb. t. 13. f. 3.?

Loc. Hythe.

A large and handsome species allied to *A. Astierianus*, but more compressed.

155. *Ammonites inflatus* Sow. M. C. t. 178.

Loc. Atherfield.

156. *Ammonites*?

Fragment of a species from Hythe, allied to *A. consobrinus* D'Orbigny, T. C. pl. 47., but too imperfect for certain determination.

157. *Ammonites*?

Fragment of a very distinct species from Peasemarsch, resembling *Ammonites Leopoldinus* D'Orbigny, T. C. pl. 22.

158. *Scaphites grandis* (*Hamites* sp.) Sow. M. C. t. 593. f. 1.

SYN. *Scaphites Hillsii* Sow. in Fitton, G. T. 3d ser. t. 15. f. 1, 2.

Ancyloceras grandis et *Hillsii* D'Orbigny.

Var. β . *Crioceras Bowerbankii* (*Tropæum* sp.) Sow. Geol. Tr. 2d ser. vol. v. t. 34. f. 1.

Loc. Atherfield.

NOTE. I can find no certain characters by which to distinguish between the several fossils brought together here under *Scaphites grandis*. The original figure of the Mineral Conchology represents the anterior portion of the same shell, entire specimens of which constitute the *Scaphites Hillsii*, whilst the *Crioceras Bowerbankii* differs only in the anterior portion being in juxta-position with instead of disjoined from the posterior whorls, a difference which can only be regarded, in the absence of other characters, as a local variation. I have placed the species in the old genus *Scaphites*, under which it appears to me most of the cretaceous species of *Scaphites*, *Crioceras*, and *Ancyloceras*, may be naturally grouped, admitting as a character distinguishing them from *Ammonites*, the greater or less disunion of the whorls, and from *Hamites*, the spiral arrangement of the posterior volutions. The genus *Helicoceras* of D'Orbigny seems to me to be founded on the young states of his *Ancyloceras*, as are also many of the species of *Crioceras*.

159. *Hamites*. (Imperfect specimens.)

Loc. Hythe.

(End of the Mollusca.)

III. DESCRIPTION
OF
SOME FOSSIL REMAINS
OF
DINOTHERIUM, GIRAFFE, AND OTHER MAMMALIA,
FROM THE GULF OF CAMBAY, WESTERN COAST OF INDIA,
CHIEFLY FROM THE COLLECTION PRESENTED BY
CAPTAIN FULLJAMES, OF THE BOMBAY ENGINEERS,
TO THE MUSEUM OF THE GEOLOGICAL SOCIETY,
BY
H. FALCONER, M.D. F.R.S. F.L.S.*

DURING the late meeting of the British Association, at Cambridge, I made a communication† to the Geological section on some new additions to the Fossil Fauna of India, from Perim Island, in the Gulf of Cambay. Among these were mentioned a species of *Dinotherium*, *Giraffe*, and a new Ruminant genus of a size nearly equalling the *Sivatherium*, found associated with remains of *Mastodon*, *Elephant*, *Rhinoceros*, *Hippopotamus*, and several species of Ruminants. The occurrence of *Dinotherium* in the extinct Fauna of India, is a point of such interest, that no delay ought to take place in laying before palæontologists the evidence upon which the statement is founded; and as the Geological Society possesses the largest collection of Perim Island fossils to which I have had access, including remains of most of the species to be noticed in the sequel, the pages of its journal are the fittest place for this communication, the main object, indeed, of which is to do justice to the meritorious labours of Captain

* NOTE BY THE PRESIDENT. — The following letter with reference to the subject of this Memoir has been received from Dr. Falconer: —

To the President of the Geological Society.

SIR,

HAVING had occasion to examine the Indian fossils in the Museum of the Geological Society with reference to the work on which I am at present engaged on the extinct Fauna of Northern India, and having found in the collection of fossil bones from Perim Island, presented to the Society in 1840, by Captain Fulljames, several remains of the highest interest which have not yet been described, I have in compliance with your desire made a brief description of them which I have now the satisfaction of forwarding.

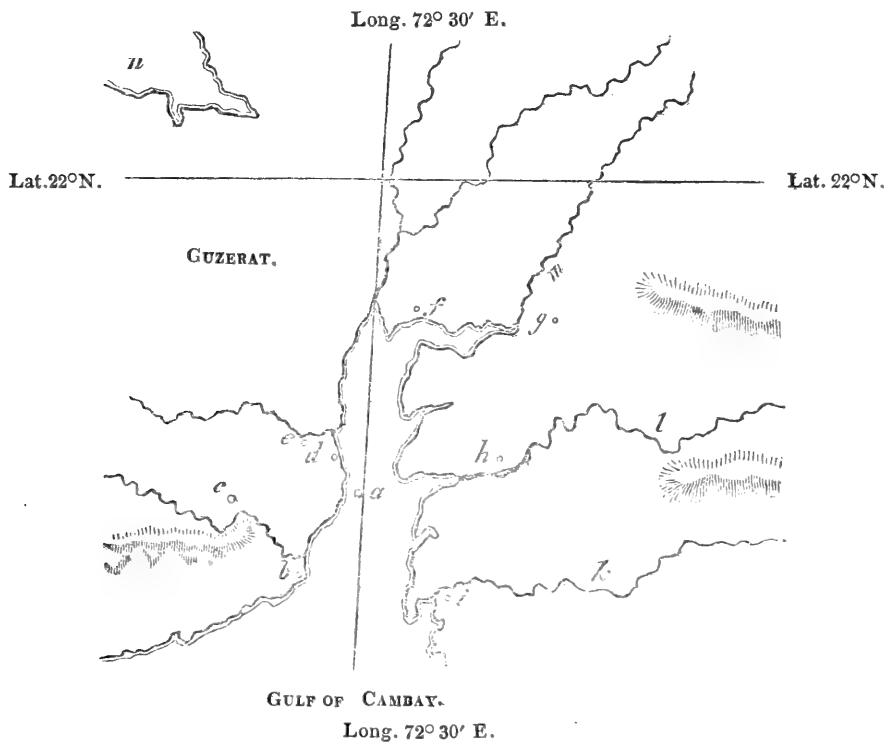
I have the honour to be, Sir, your most obedient Servant,
London, July, 1845. H. FALCONER.

The collection of fossil bones presented to the Geological Society by Captain Fulljames not having been accompanied by any memoir, and no description of it having yet been given in the publications of the Society, the President and Council have not hesitated to deviate from their usual course with regard to the publication of memoirs, and have directed the insertion of Dr. Falconer's communication in the present number of the Journal of the Society.

† This communication was read on Tuesday, 24th June.

Fulljames, of the Bombay Engineers, one of the earliest and most successful explorers of the ossiferous beds of Perim Island. This is the more called for, as considerable delay has occurred in the description and determination of the remains which that officer collected and transmitted to England several years ago.

Perim* is a small island, situated in lat. $21^{\circ} 31'$, in the Gulf of



MAP of the District near PERIM ISLAND. *References.*

- | | | |
|------------------|----------------|-------------------|
| a. Perim Island. | e. Bhownuggur. | i. Surat. |
| b. Gopenaut. | f. Cambay. | k. Tapti River. |
| c. Politana. | g. Baroda. | l. Nerbudda R. |
| d. Gogah. | h. Baroche. | m. Mhye R. |
| | | n. Gulf of Gutch. |

Note. Between the Nerbudda and Tapti rivers is the river Keem, the mouth of which is seen, but whose course is not indicated on the map.

Cambay, nearly opposite the estuary of the Nerbudda River, and separated about 500 yards from the coast of Kattiwar in Guzerat, by a channel which Captain Fulljames states to be 75 fathoms deep. The island is about three miles in circumference, being from one and a half to two miles in length, and in breadth one half to three-quarters of a mile. The only particulars regarding its structure, with which I am acquainted, have been given by Captain Fulljames and Dr. Lush.† The highest point of the land is said to be not more than 60 feet above high-water mark. The western side presents cliffs of conglomerate, of about 30 feet above the sea, “the upper strata

* Captain Fulljames, *Journ. Asiat. Soc. of Beng.*, vol. v. p. 289.

† *Loc. citat.* Lush, *idem.* vol. v. p. 767.

being of compact sandstone, all perfectly horizontal." * Captain Fulljames describes the order of succession, commencing from the surface, as thus :—

1. Loose sand and gravel.
2. Conglomerate, composed of sandstone, clay, and silex.
3. Yellow and whitish clay, with nodules of sandstone.
4. Conglomerate, as above (No. 2.).
5. Calcareo-siliceous sandstone, with a few fossils.
6. Conglomerate.
7. Indurated clay, more or less compact.
8. Conglomerate, being the principal ossiferous bed.

No precise measurement is given of these beds, but the deepest strata of conglomerate are described to be about 3 feet thick, although, in general, they do not run more than 18 inches to 2 feet, and for the most part are horizontal. "On the western side of the island, however, the strata are much disturbed, being fractured and dipping at an acute angle to the east. On the southern end of the island, sandstone appears below the fossil stratum of conglomerate, dipping to the north at an angle of 25°." "Capital fresh water is procurable on the island, rising from 20 feet below the surface; it is found below the stratum of sandstone." * Dr. Lush states that "proceeding from the south point towards the eastward, layers of kunkur are met with below the sandstone." He also adds that shells and other fossils are found in the conglomerate, besides the osseous remains. But none of those shells are to be seen in the specimens to which I have been able to refer, in the Geological Society's collection, or at the British Museum.

Our information regarding the geological structure of both sides of the Gulf of Cambay, is at present exceedingly imperfect; but much may be expected when the unpublished researches of the lamented Malcolmson are brought out, as he is known to have carefully determined the succession and age of the tertiary beds along the coast of the Northern Concan. In regard to what is known, Dr. Lush describes the sandstone of Bombay as appearing at Mahim, Seergaum, and Danù, in horizontal strata, and "evidently above the trap." At Gundavie, the shell sandstone disappears, and beds of clay and kunkur present themselves in the line of section from Gundavie to Surat. From this point to the Keem River, nothing is seen but the "black cotton soil;" on the right bank of the Keem, sandstone and conglomerate are exposed, according to Dr. Lush, in the following order:—

Section on the Right Bank of the Keem.

- | | | | |
|--|---|---|---------|
| 1. Alluvial soil with masses of conglomerate | - | - | 6 feet. |
| 2. Horizontal beds of sandstone in thin layers | - | - | 3 feet. |
| 3. Sandstone | - | - | 5 feet. |
| 4. Coarse conglomerate (bed of the river). | | | |

Respecting the Kattiwar coast, nearest which Perim Island is

* Lush, *loc citat.*

† Fulljames, *loc. citat.*

placed, Dr. Lush mentions the conglomerate as reappearing at Gogah, close to the island, where masses of the rock containing shells are dug out of the beach. This conglomerate appeared to him to contain no fragments of trap, although the central ridge of Kattiwar, including the hill of Politana, is composed of trap, which is also seen at Bhownuggur.* Captain Fulljames states that he has found “a similar formation to that of Perim all along the coast from Gogah to Gossnath Point, where a firm sandstone is quarried, and of which the splendid Srāwak temples of Politana are built.” Captain Fulljames, in a separate paper †, gives an account of the strata passed through, in an experimental boring at the town of Gogah. Of the 320 feet mentioned in the section, the uppermost 74 consist of sand and gravel 11 feet, stiff black clay 6 feet, sand and clay 10 feet, soft sandstone alternating with thin seams of different coloured clays, sand, and gravel 13 feet; and lowermost, a very hard siliceous sandstone 9 feet thick. The inferior portion of the section is composed of a great bed of dark clay, which has been penetrated down to 246 feet, containing pyrites and broken shells. The whole of this mass appears to be above the conglomerate, but it is not shown whether the absence of the clay deposit at Perim is owing to denudation, or to its upheaval before the clay on the coast was deposited. Captain Fulljames states that he had discovered fossil remains, like those of Perim Island, down the coasts towards Gossnath, and in a similar formation.

The first announcement of the Perim fossils is given in a communication, dated 17th April, 1836, by Baron Carl von Hügel ‡, in which he mentions their having been discovered by Dr. Lush. Among the remains which he enumerates are, bones of the *Mastodon latidens*, the core of the horn of a species of *Bos*, the head of a boar, and a rodent. Captain Fulljames concedes the priority of discovery to Dr. Lush; but immediately after followed up the inquiry by more extended researches, commencing in April of the same year; and it is to him that we are indebted for the greater part of the Perim fossils, which are to be found in the museum of the Asiatic Societies of Calcutta and Bombay, and of the Geological Society of London. Among those which he first met with, he mentions “teeth of *Mammoth*, *Mastodon*, *Palæotherium*, *Hippopotamus*, *Rhinoceros*, and a number of other smaller animals; elephant’s tusks; the head of some large saurian animal; tortoise; one-half of a deer’s foot; and a shell in siliceous sandstone.” In the collection which Captain Fulljames sent to the Asiatic Society of Calcutta, Mr. James Prinsep § enumerates “many jaws of the *Mastodon* in fine preservation; also teeth or jaws of the *Hippopotamus*, *Elephant*, *Rhinoceros*, a large animal assimilating thereto (*Lophiodon*?), *Sus*, *Anthracotheurium* (?)

* Dr. Malcolmson however (vide *post* p. 367.) mentions the occurrence of trap pebbles in these same tertiary beds.

† Jour. Asiat. Soc. of Beng., vol. vi. p. 787.

‡ Ib., vol. v. p. 288. (May, 1836.)

§ Loc. citat., vol. v. p. 290.

“*Deer, Ox*, many vertebræ and unidentified bones and horns ; tortoise fragments, and a peculiarly perfect Saurian head.”* These identifications are not to be considered, in several of the instances, as more than approximative ; for neither of these gentlemen profess to be familiar with the subject of fossil bones.

No further account of these remains has appeared in any of the Indian journals since that time. In 1840, Captain Fulljames sent his donation to the Geological Society, and about the same time some specimens from the same locality were presented by Miss Pepper to the British Museum.

Judging from the matrix which adheres to them, the Perim fossils seem to be imbedded, in most cases, in a calcareo-ferruginous conglomerate, composed of nodules of indurated yellow clay, cemented together by a paste of sand and clay. Some of them are attached to patches of a hard argillaceous sandstone. Many of them have had the matrix washed off by the action of the sea, and are in this case generally covered over with the remains of small species of serpula and other recent marine shells. The mineral character of the bones shows that they are penetrated with siliceous infiltration, like a great portion of the Sewalik fossils ; and in consequence they present a great degree of hardness. The same character holds in many of the osseous remains from the crag ; like the latter, the Perim bones, under the action of the sea, wear down into a polished vitreous surface.

DINOTHERIUM. See Pl. 14. fig. 1. 1a.

The first of these remains to be noticed is a fragment (figs. 1. and 1a.) consisting of the posterior half of one of the inferior molars of a species of *Dinotherium*. The correspondence of the specimen with the teeth of the large European species is so complete in the form of the gable-shaped grinding ridge, its transverse direction, and the reflected marginal bulges into which it swells out on either side, together with the characteristic crenulation of the edge, that there can be no doubt of its belonging to the genus *Dinotherium*. The peculiar “talon” or heel ridge is developed in the same degree and with a like amount of crenulation along its edge. The fragment is represented in section in fig. 1a., the internal structure exhibiting the same agreement with that of the European *Dinotherium* indicated by the external form. The centre is occupied by a rhomboidal core of arenaceous matrix marking the form of the unossified pulp nucleus. I have compared it minutely with a corresponding section of the same tooth (the penultimate of the lower jaw) of *Dinotherium giganteum* (figs 2. and 2a.) from Eppelsheim ; and the only perceptible difference is, that the angle formed by the ridge of the ivory is more acute, and the enamel thicker in the Indian than in the European form. Perhaps no conclusion can be safely drawn from this observed difference of angle in the ivory ridge ; as it may be a peculiarity of the individual. The greater thickness of enamel is probably of more importance, and may represent a mark of

* Jour. Asiat. Soc. of Beng. vol. vi. 78. (January, 1837.)

specific distinction. The specimen, however, is much too defective to warrant any opinion in regard to the relations of the Perim fossil to the European species, except that it was quite as large as the *D. giganteum*. We are fortunately able to determine the position of the tooth in the jaw with some confidence. The upper grinders in *Dinotherium* have a long low basal ridge in front and behind; while the same teeth in the lower jaw have hardly any ridge in front, and the hind one is considerably more developed than in the upper grinders, so as to form a strongly marked "talon" or heel. The Perim fossil exhibits this heel of large size, while the presence of an impression on the posterior surface proves that there was a tooth behind it. It, therefore, belonged to the penultimate molar of the lower jaw, and apparently to the left side.

In short, there can hardly be a doubt about the specimen belonging to a species of *Dinotherium*. The only question which can arise is in regard to the correctness of the locality whence the specimen is said to have come. It was presented to the British Museum by the lady whose name is mentioned above, as a Perim Island fossil, along with teeth specimens of a species of mastodon known to be found in the Perim deposit. M. König, the eminent conservator of the Palæontological department, who had early recognised the generic relations of the fossil, is confident about the donor and the mentioned locality. An additional confirmation is met with in the mineral condition of the specimen. It exhibits the silicified appearance, which is so prevalent in the Ava, the Sewalik, and Indian fossils generally. The ivory core is fissured into a vast number of radiating minute segments which have been re-cemented by a siliceous paste (as has happened to certain agates), and the whole of the structure, — enamel and ivory, — has become so thoroughly penetrated with siliceous infiltration, that it resists the knife and takes on the highest degree of vitreous polish in the section, while the external surface of the enamel, from the same cause, presents an opaline appearance. All the Eppelsheim specimens of *Dinotherium*, which I have had an opportunity of examining, are, on the other hand, unsilicified, softer, and of less specific gravity. In section their ivory cuts under the knife, and yields a dull earthy surface; while the harder enamel takes on but a very imperfect polish. This circumstance strongly confirms the Indian origin of the fossil. It is very possible that the large animal — "assimilating to the rhinoceros (*Lophiodon* ?)" — mentioned by Mr. James Prinsep in the quotation above given, may also belong to *Dinotherium*. This conjecture is thrown out for the guidance of those connected with the museum at Bombay and that at Calcutta, who have access to the original specimens. What we know at present must serve in a great measure as an index merely to further inquiries. I would suggest in the meantime designating the Perim fossil provisionally, by the specific name of *Dinotherium Indicum*.

The following are the dimensions of the fragment compared with those of the same tooth of the *Dinotherium giganteum* from Eppelsheim.

	Perim Fossil.	Eppelsheim Specimen.
	inc.	inc.
Length of penultimate molar lower jaw - -	- -	3.75
Width of ditto at the posterior ridge - -	3.1	2.75
Length in section of the posterior ridge of ivory at base - - - - -	1.5	1.75
Height of ditto - - - - -	.63	.63
Thickness of the enamel - - - - -	.25	.19

The fossil is represented in the figures of the natural size.

GIRAFFE (*Camelopardalis*). Pl. 14. fig. 5.

This figure represents a fragment comprising the posterior half of the second cervical vertebra of a giraffe, a good deal mutilated. It shows the characteristic form of the body of the vertebra in this genus, and the cup-shaped articulating surface for the head of the third cervical vertebra. The upper half is wanting, and the posterior oblique processes are broken off. Along the middle of the body, there is a well-marked longitudinal ridge, corresponding exactly in form and development to that mentioned as characterising the third cervical vertebra of the *Camelopardalis Sivalensis* described in the Proceedings of the Geological Soc. (vol. iv. p. 242.); the same remark applies to the lateral ridges of the body, which are decurrent from the inferior transverse processes terminating at the posterior end of the bone in thick expansions. This part of the vertebra is differently formed in both respects in the existing species. The same resemblance is further shown by the spinous process, the projecting part of which, as in the Sewalik specimen, is placed lower down on the arch than in the living species. The mutilated condition of the fragment prevents the form of this process from being well ascertained; but the very low position and shape of the most salient part determines the vertebra to have belonged to the second of the neck series. There is enough remaining to indicate that there was a like correspondence with the Sewalik fossil in the curve of the body on its under surface, which is more arched than in existing giraffes. The specimen is so weathered and abraded as to present only few points for measurement; but such as may be taken indicate the closest agreement between the fossils:

	Perim Island Fossil.	Sewalik Fossil.
	inc.	inc.
Greatest width at the posterior end of the body between the transverse processes - -	3.1	3.1
Vertical diameter of articulating cup - -	2.1	2.
Transverse diameter of ditto - - -	2.1	2.

The Perim fossil, like the Sewalik one, is proved to have belonged to an adult and even aged animal, by the marked relief of the ridges, the depth of the muscular depressions, and especially by the circumstance that the posterior articulating surface is completely synostosed with the body of the bone, which is not the case in young animals. With this united correspondence in form, size, and other particulars, I have little hesitation in referring the Perim Island fossil to the second cervical vertebra of the *Camelopardalis Sivalensis*. This specimen is from the collection sent by Captain Fulljames to the Geological Society.

BRAMATHERIUM. Pl. 14. fig. 3., 3a., 4a., 4.

The next of these remains to be noticed are of great interest, as they appear to indicate a large and peculiar form of Ruminants, nearly equalling the *Sivatherium* in size, but at the same time essentially different. The remains consist of two fragments of the left side of the upper jaw, including the entire series of the superior grinders. Although, probably of the same species, they are certainly not derived from the same individual. The first fragment (fig. 3.) is from the collection sent by Captain Fulljames to the Geological Society. It contains the three false or premolars nearly perfect, together with the broken remains of the first true molar. The surface of the enamel (fig. 3a.) shows the rugosely furrowed character, which is found in the *Sivatherium*; but the whole of the teeth in the fossil are at once distinguished from those of that genus, by the absence from all of them of the sinuous plaited flexures, which the inner crescent of enamel presents in it: they also want the basal collar or "burr" on the inside, which is seen in those of *Sivatherium*. With these discrepancies, which are of considerable importance in the Ruminantia, from the constancy of such modifications in the different groups of this order, the premolars of the fossil correspond in general form, and in the relative proportion of width to length with those of *Sivatherium*. The only other genus of Ruminants which shows the peculiar rugose enamel furrowing, in a marked degree, is the giraffe, which agrees with the Perim fossil in the simple direction without fold, of the inner crescent of enamel. But, in this genus, the upper premolars are distinguished from those of all other Ruminants by their great excess of width compared with their length. In this respect, and further in being considerably more oblique, both in form and in their relative position in the jaw, these teeth in the Perim fossil differ from those of the giraffe. The dimensions of the fossil contrasted with those of the *Sivatherium giganteum*, and of the skull of an adult male giraffe in the collection of the College of Surgeons, are as follow:—

				Perim Fossil. No. 1.	Sivathe- rium giganteum.	Male Giraffe.
				inc.	inc.	inc.
Length of the three premolars	-	-		4	4.5	2.9
Length of the 1st premolar	-	-	-	1.5	1.75	.9
Width of the 1st	—	-	-	1.3	1.63	1.1
Length of the 2d	—	-	-	1.4	1.5	1.
Width of the 2d	—	-	-	1.5	1.75	1.1
Length of the 3d	—	-	-	1.25	1.75	1.
Width of the 3d	—	-	-	-	1.9	1.2
Length of the 1st or antepenultimate true molar				1.6	1.6	1.33

The second specimen (fig. 4. and 4*a.*), (for an examination of which I am indebted to the kindness of Major Jervis, of the Bombay Engineers,) is also from Perim Island, and shows the hindmost premolar, together with the three back or true molars nearly perfect. Like the premolar of the other specimen, these teeth, besides being smaller, differ from their equivalents in *Sivatherium giganteum*, by the absence of the flexuous direction of the enamel, and of the basal ridge at the inside. In these particulars, and also in the presence of a minute or rudimentary cone of enamel on the inner side at the base, between the barrel divisions of the teeth, but attached only to the posterior lobe, they correspond with the other molars of the giraffe. But the anterior pillar of enamel, on the outer surface of the front half of these teeth, is considerably thicker in proportion in the fossil than in the giraffe; while the outer surface of the posterior half is more expanded in length, and is more hollow than in the latter genus. A still more important difference is, that in the fossil there is no tendency to a basal mammilla or enamel lobe at the outside between the barrel divisions of the two backmost molars as in the larger fossil giraffe of India (Geol. Proceed. *antè cit.* pl. ii. figs. 3., 3*a.*, and 4.); while the middle of each of these divisions at the inner side is so compressed vertically, as almost to present an obsolete or indistinct form of keel. The following are the comparative dimensions as in the case of the previous specimen.

				Perim Fossil. No. 2.	Sivather. Gigant.	Male Giraffe.
				inc.	inc.	inc.
Length of the series of three back molars	-			4.63	5	3.9
Length of the 1st	—	-	-	1.6	1.63	1.33
Width of the 1st	—	-	-	1.75	2.	1.97
Length of the 2d	—	-	-	1.75	2.	1.37
Width of the 2d	—	-	-	1.9	2.	1.37
Length of the 3d	—	-	-	1.6	2.	1.37
Width of the 3d	—	-	-	-	1.75	1.37

It is not necessary to follow up the comparison of the fossil teeth with those of the *Bovidæ*, *Cervidæ*, and other families of the

order, from all of which they appear to be more removed than from the *Sivatherium* and *Giraffe*. The molars of the Ruminantia generally are formed so much upon the same plan, that it is not easy to draw sufficient generic distinctions from them alone. The characters presented by these Perim fossils, so far as they go, certainly distinguish them from the *Sivatherium*, and also from the giraffes, fossil and recent, but their nearest affinity appears to be with the latter genus: and they probably belong to the same family. The materials presented here, as in the case of the *Dinotherium*, are much too scanty at present for any conclusive opinion on the subject. Meanwhile, under the conviction of the generic distinctness of the Perim Ruminant, I propose considering it as a genus under the name of *Bramatherium**, with the specific title of *B. Perimense*, to mark the rich and interesting fossil locality where it was found.

The *Dinotherium*, *Giraffe*, and *Bramatherium* are the only Perim fossils which it is intended to particularise by description in this communication. But Captain Fulljames's collection includes specimens of a great many other forms, which prove that the clay conglomerates of the Gulf of Cambay contain entombed in them the remains of a very extensive and varied fauna. Among them there occurs one species of *Mastodon*, one of *Elephant*, a large species of *Rhinoceros*, *Hippopotamus*, *Sus*, *Equus*, several species of *Antelope*, *Bos*, two species of *Crocodile*, one of which is of the *Gavial* type; several forms of fresh-water *Tortoises*, with fish vertebræ two and a half to three inches in diameter. These will be noticed in detail, in the work upon which Captain Cautley and myself are engaged, on the fossil fauna of the Sewalik Hills. The principal point of interest about them, requiring mention on this occasion, is, that the mass of the Perim fossils belong to the same genera and species which are found in the Sewalik Hills, and in the ossiferous beds of the Irawaddi in Ava. We have thus conclusive proof that, in the later tertiary period, as at present, one and the same vertebrate fauna ranged from the banks of the Irawaddi, on the eastern side of the Bay of Bengal, 1700 miles up along the foot of the Himalayahs, to the Indus, where it escapes from these mountains, and thence across the continent to the western side of India. We are now getting the first glimpse of the evidence, regarding the range and distribution of the species. Some, as at present, were common over the whole extent of country, while others appear to have been limited to, or had their force of development in a particular tract. The prevailing species of *Mastodon* from Perim is identical with one of the forms described by Mr. Clift, under the name of *M. latiuens*, in his excellent memoir in the *Geol. Transact.*, 2d. Ser. vol. ii.

* The name *Sivatherium*, derived from the Hindoo God *Siva*, having been admitted for one great fossil Ruminant from India, *Bramatherium*, derived from the God *Bramah*, may conveniently be applied to another: the ordinal relationship of the two will thus be easily remembered, together with their common Indian origin.

p. 371., this nominal species appearing to include two very distinct forms. One of these (Mr. Clift's, pl. 37. figs. 1—4) seems to have been common on the western side of India, and in Ava, while it is but rarely found in the Sewalik Hills. The Perim *Sus* is identical with a Sewalik species (*Sus Hysudricus* Fal. and Caut.); and a like agreement has been noticed as holding with one species of Giraffe. The Dinotherium and Bramatherium have not yet been observed amidst the fossils of the Sewalik Hills, while the gigantic tortoise (*Colossochelys Atlas*) ranged from the Sewalik Hills to the Irawaddi.* The Hexaprotodon form of Hippopotamus occurs in Perim Island, Ava, the valley of the Nerbudda River, and the Sewalik Hills.

I have had occasion, in more than one instance, in joint communications with Captain Cautley to the Geological Society, to refer to the singular richness of the ancient Fauna of India, in mammiferous forms. As a general expression of the leading features, it may be stated that it appears to have been composed of representative forms of all ages, from the oldest of the tertiary period down to the modern, and of all the geographical divisions of the old continent grouped together into one comprehensive fauna, in the countries along the valley of the Ganges. The Dinotherium of the miocene period of Europe was, till now, a notable exception; but the fossil described in the preceding pages shows that ancient India was not without a representative of this most remarkable genus. In addition to most of the known types of Ruminants, we have now evidence that the same country had, in the Sivatherium and Bramatherium, at least two colossal forms of this order.

In regard to the precise determination of the age of the ossiferous deposits of India, the problem still remains to be solved. The western coast of the peninsula will, in all probability, furnish the most certain and numerous data for its solution; as we may expect there to find deposits and organic contents corresponding to the numerous alternations of upheavement and submergence which the land on that side of the continent has undergone. Fossil remains of Elephant, Hippopotamus, Equus, &c., were discovered by Dr. Spilsbury †, in the valley of the Nerbudda, near Jabalpur, in a bed of limestone capped by a thick mass of basalt, and traces of mammiferous remains have been found in other parts of the basaltic district of Central India. Extensive lacustrine deposits disrupted and altered by the same igneous rock have been met with over a wide extent of the Deccan, containing the same species of *Paludina*, *Physa*, *Limnea*, *Unio*, and *Cypris*. ‡

Reasoning from these facts, Dr. Malcolmson was led to the inference "that the part of the Vindhya range near Mandoo was

* There are fragments of this great Chelonian among the fossils brought by Mr. Crawford from Ava.

† Jour. Asiat. Soc. of Bengal, vol. ii. p. 583.

‡ Malcolmson, Geol. Trans. series 2. vol. v. p. 570.

“elevated during the same comparatively recent epoch as the Sichel Hills, between the Godavery and Taptee, the Gawulgurh range, and the Satpoora mountains, south of the Nerbudda.” He adds also the following startling generalization: “Over all these tracts then I am justified in believing that at one time extensive lakes and marshy plains existed, full of the ordinary forms of lacustrine life. The precipitous and thirsty mountain ranges which intersect India, and which now rise bare and burnt up in inaccessible cliffs, which for months of every year hardly afford water for the birds of the air, must then have exhibited vast plains, full of fresh-water lakes and marshes, on the muddy shores of which multitudes of gavials, crocodiles, and tortoises must have preyed; and amidst the rank luxuriance of the bordering vegetation the *Mastodons*, *Hippopotami*, *Bisons*, and *Sivatheria*, must have ranged, whose bones are now found so abundantly scattered over India.”* Unfortunately, this excellent observer’s researches on the Gulf of Cambay have never been published; but in a note appended to the paper quoted above, he mentions the occurrence of trap pebbles in the tertiary sandstones of Perim Island and Kattiwar, (see *antè*, p. 359.) and in the cornelian conglomerates of Rajpeeppla and Broach, which are said to be remarkably altered by the intrusion of igneous rocks of a late date.

Supplementary Observations. Since the preceding remarks were in type, I have had occasion to examine some other Perim Island fossils presented to the British Museum by Miss Pepper: one of which has furnished additional and most unequivocal evidence of a huge Indian species of *Dinotherium*. The specimen is a superb fragment of the left half of the lower jaw, containing nearly the whole of the adult series of five molars in situ. The contour of the body of the jaw is shown in the most perfect state of preservation, the fossil having fortunately been mineralised by means of a very hard siliceo-ferruginous infiltration. But it has evidently been long rolled about on the sea-beach as a boulder, so that the crowns of the whole series of molars have been hammered off nearly level with the alveolar margin of the jaw; the surface of the fossil is jet black, and almost all of the matrix has been cleared away, probably by the long-continued action of the sea, which has given it a semi-vitreous polish. That it had latterly been in the sea is distinctly proved by adherent patches of recent marine shells identical with those found on others of the Perim fossils: and the testaceous remains being white, pearly, and fresh-looking, are seen in marked relief upon the black surface of the fossil. The symphysis of the jaw is broken off about $2\frac{1}{2}$ inches in front of the anterior premolar, and the bone is truncated behind exactly opposite the point where the coronoid margin of the ramus begins to rise up, the

* Malcolmson, *Journal Bombay Geograph. Society*, vol. for 1841—1844, p. 371.

fracture passing through the middle of the last molar, the anterior ridge of which is visible in situ in the jaw.

The dimensions given below will indicate most distinctly the characters by which this fossil differs from the jaw of the *D. giganteum* of Kaup. In relative length, the two agree very closely, the four anterior molars measuring but half an inch more in the Indian than in the European species. But the other proportions are very different. The depth of the jaw measured to the alveolar margin of the second premolar, where the deflexion of the symphysis begins alike in both, is 9·2 inches in the former, while it is but 6·9 in the latter, and at the back of the third tooth or first true molar, 8·7 inches to 6·2 inches. The Perim fossil exhibits a like excess of dimensions in relative thickness, the jaw measuring 5·1 inches in diameter under the second premolar, and 6·4 inches at the middle of the penultimate molar, while in the European species the corresponding dimensions are respectively 4 and 5 inches. In consequence of this great depth and thickness, the jaw of the Indian fossil approaches very closely the massive and turgid form seen in the typical mastodons, such as the *M. giganteus*; while that of the European *Dinotherium* is comparatively much thinner and more compressed. The inner side of the jaw in the latter is very flat, differing in this respect widely from the mastodons generally: in the Perim fossil this flatness is much less, not exceeding that of the *Mastodon giganteus*, and behind the body of the jaw bulges out on either side, so as to yield nearly a circular outline in section, and exactly to represent the form in the American Mastodon. This resemblance is so great, that in the absence of the crowns of the teeth, and from its huge proportions, the fossil, when presented to the Museum, and up to this time, has always been regarded as the jaw of a Mastodon. The relationship indicated by the shape of the jaw, is further borne out by the form and structure of the penultimate lower tooth, as described in the preceding part of this paper. The enamel, which is thinner in the *D. giganteum*, is as thick in the Indian species as in the lower penultimate of the American mastodon: the outline of the ivory ridge beneath the enamel is the same in both; the crown ridges have the same transverse, continuous, crenulated, and trenchant form; and what is most important and significant of all, the hind talon, in respect of form, amount of development, and the characteristic crenulation of its edge, is so precisely similar that this part in the one exactly represents the corresponding part of the same tooth in the other. The same direction of affinity is further indicated by the nearly horizontal line of protrusion and horizontal plane of wear in the teeth, by the form of the ramus, coronoid process, and angle of the jaw, and by the absence of antero-posterior curvature in the outline of its lower surface, in all of which particulars the American Mastodon deviates widely from its congeners, and from the Elephantine type generally, and approximates towards the *Dinotherium*. This tendency is also shown in the very reduced formula of the teeth ridges, in the deflexion of the symphysis,

its thick bluff termination, and in the inferior tusks. I shall soon have occasion in another place to follow up this subject at greater length, and in the meantime must content myself with the simple statement, that the North American Mastodon and the Indian Dinotherium are the nearest connecting forms of the two genera yet known, and that their relationship is far from being remote, perhaps even nearer than that of the American Mastodon to the Indian Elephant or the Mammoth.

The deflexion of the symphysis commences immediately behind the second molar, as in the *Din. giganteum*, and it is evidently produced into a great bluff mass, bent downwards as in that species. The section at this point does not include any part of an inferior tusk, or of an alveolus for it; but Dr. Kaup* tells me that the large tusks of the Eppelsheim species, with their alveoli, always terminate considerably in front of the anterior premolar. There is no reason, therefore, to conclude that the Indian had not tusks resembling those of the European species: and although there is no direct evidence to the point, everything in the construction of the symphysis goes to support the presumption that there were tusks. The posterior mentary foramen is of large size, and situated at the outside under the anterior premolar, exactly as in the Eppelsheim fossil, but at a greater distance from the alveolar border of the jaw. It is much larger than the foramen seen in the cast of the Eppelsheim lower jaw; but no faith can be put in the dimensions of a foramen measured on a cast.

In regard to the teeth, nothing is seen of their crowns, which have been broken off close to the alveolar margin: but the bony partitions between five teeth are distinctly visible, showing the usual complement in Dinotherium, and proving that the fossil was derived from an adult animal. These five teeth consist of two premolars, and three true molars. They diminish in width from the backmost forwards, as in the European species. The anterior premolar has two lobes, the front one being compressed and sharpened off forwards into a cuneiform edge; the rear lobe being shorter and broader. This tooth is upwards of half an inch longer than that belonging to the jaw of the great specimen figured by Kaup. The second premolar is nearly square in outline, but wider behind. It appears to have had two ridges, and four fangs. The third tooth or first true molar, presents a length of 4 inches by 2·8 of extreme breadth; while that of the Eppelsheim cast measures 3·6 by 2·6. We have in this excess of length conclusive proof that the Indian, like the European species, possessed the remarkable character of having the first true molar three-ridged, and more complex in its form than the two backmost

* I have had the advantage, while engaged on the examination of this fossil, to benefit, during his present residence in London, by the intimate knowledge of the structure of the Dinotherium, possessed by this distinguished palæontologist, the founder of the genus. Dr. Kaup was at once convinced of the generic relations of both the fossils, but he is in nowise responsible for any of the opinions here advanced regarding the distinctness of the species, or its affinities.

grinders. The crown is so utterly mutilated as to afford no evidence regarding the form of these ridges. The second, or penultimate true molar is nearly square in its plan outline, but more than half an inch longer and wider than in the European species. The tooth specimen described in the body of this paper was inferred to be the penultimate inferior, and it was probably derived from a female or small-sized individual. The remains in the jaw appear to indicate that this tooth was two-ridged, with a talon as in the European species. Of the third and last molar only the anterior half remains, and we have no direct proof how many ridges it bore; but the number was most probably two, with a talon, as in the European species. The portion which remains presents two distinct and slightly divaricating fangs, indicating, among many others which could be added, another character of resemblance to the North American mastodon.

The following are the dimensions of the fossil compared with those of a cast of the jaw of the great head specimen, supposed to have been a male, figured and described by Kaup.

	Mastodon giganteus.*	Dinotherium Indicum, from Perim Island.	Dinotherium giganteum of Eppelsheim.
	inches.	inches.	inches.
Length of the fragment - - -	- - -	17.	
Ditto of the 4 anterior teeth - - -	- - -	13.5	13.
Ditto of the first premolar - - -	- - -	3.5	2.9
Width of ditto behind - - -	- - -	2.2	2.2
Length of 2d ditto - - -	- - -	2.9	3.3
Width of ditto behind - - -	- - -	2.6	2.7
Length of 3d or first true molar tooth - - -	- - -	4.	3.6
Width of ditto behind - - -	- - -	2.8	3.
Length of 4th tooth (2d true molar) - - -	- - -	3.9	3.3
Width of ditto - - -	- - -	3.5	2.9
Depth of jaw to alveolar margin at the 2d premolar - - -	7.5	9.2	6.9
Ditto at 3d tooth (1st true molar) - - -	6.6	8.7	6.2
Width of jaw at 2d premolar - - -	5.7	5.1	4.
Ditto at the middle of 4th tooth (or penultimate true molar) - - -	6.5	6.4	5.
Distance between the upper margin mentary foramen and alveolus of 1st premolar - - -	- - -	3.6	2.2
Ditto from inferior margin to ditto - - -	- - -	4.75	3.4

* N.B. The four measurements of *Mastodon giganteus*, given for comparison, are taken at points of the jaw corresponding to those of the *Dinotheria*.

The *Dinotherium* of Eppelsheim is known to range through a very wide difference of size, dependant on sexual or individual peculiarities, and several nominal species, chiefly founded upon this character, have been described by authors. But Dr. Kaup informs me,

that he now admits but two species, *D. giganteum* and *D. Koenigii*, as he regards all the rest, such as *D. Cuvieri*, *D. Bavaricum*, *D. proavum*, &c., to be merely dwarfed varieties, or females of *D. giganteum*. M. De Blainville has arrived at nearly the same conclusion in his *Osteographie*. It would be unsafe, therefore, to found any opinion regarding the Indian fossil merely on a difference of size. But, in addition to the larger dimensions, the very remarkable peculiarities in the form of the jaw, indicated by its great depth in front, the excessive width, massive form, and circular outline in section behind, together with the absence of the flattening of the inner side, which is so marked in every specimen of *D. giganteum*, taken in conjunction with the very significant difference in the thickness of the enamel, appear to furnish the strongest evidence that the Indian fossil belongs to a distinct species. It is to be kept in mind also, that all these differential characters tend, in a remarkable manner, in the direction of greater affinity with the *Mastodon giganteus*. In corroboration of this view, it deserves to be stated that, of the numerous fossil Proboscidea discovered in India we * have found that all the forms are specifically distinct from those which occur in Europe. I have now no hesitation in regarding both the Perim fossils to belong to a distinct species of *Dinotherium*, larger than the *D. giganteum*, and more closely allied to the Mastodons, which, as proposed in the preceding pages, may be called *D. Indicum*.

NOTE. — In the *Athenæum*, No. 923, p. 662., there is an abstract of a paper by Mr. A. Bettington, read to the Royal Asiatic Society, on the 21st of June of this year, giving an account of a finely-preserved cranium of a huge Ruminant, found by that gentleman in Perim Island: I have repeatedly seen the specimen, which was exhibited at the anniversary meeting of the Geological Society on the 17th of February last; but as unpublished material, which I had no authority to quote, I have not felt at liberty to refer to it in the descriptions given in this paper. Mr. Bettington institutes a comparison of his fossil with the *Sivatherium* and *Giraffe*, and considers it, so far as the abstract above quoted indicates, to be distinct from both. The circumstance that this cranium and the fossils here described are from the same locality, creates a strong presumption that they may belong to the same genus or even to the same species; but I am unable to say in how far the teeth agree, as I have not had an opportunity for making the necessary comparison. Mr. Bettington, as quoted in the abstract, appears to consider that, in addition to horn buttresses behind the orbits, there was a pair of recurved rear horns in his fossil, at the side of the occiput, placed as in the buffalo. This inference, if well founded, would be against the affinities here attributed to Captain Fulljames's fossil, should it prove to belong

* In stating this, I use the plural pronoun *we*, intending to intimate that the opinion is one in which my colleague Capt. Cautley also concurs.

to the same species. Among the remains mentioned as having been found associated with this cranium by Mr. Bettington, are species of *Mastodon*, *Rhinoceros*, several forms of *Ruminants*, *Crocodiles*, &c.

REFERENCES to the Figures in Plate 14.

- Fig. 1. *Dinother. Indicum*; — posterior ridge and *talon* of the penultimate lower molar left side seen from outside: (*a*) the ridge, (*b*) the talon.
 Fig.^a Ditto in section, showing the enamel ivory and pulp nucleus; (*a'*) ridge; (*b'*) talon.
 Figs. 2. and 2^a. The same in *Dinother. giganteum*.
 Figs. 3 and 3^a. (*a, b, c,*) the three premolars of *Bramatherium Perimense*; (*d*) the ante-penultimate or anterior true molar; (*b', 3^a*) showing the rugous surface of the enamel.
 Figs. 4, 4^a. Plan and erect views of the last premolar (*c, c'*); and the three true molars (*d, d'*; *e, e'*; *f, f'*;) of *Bramath. Perimense*.
 Fig. 5. *Camelopardalis Sivalensis*, second cervical vertebra, side view; (*b*) mesial longitudinal ridge under side of the body; (*e*) alæform expansion of the transverse processes; (*g*) inferior oblique process; (*h*) ridge of the spinous process.

N. B. — The figures in the plate are drawn to the natural size.

Fig. 4 a.

Fig. 4

Fig. 3.

Fig. 3 a.

Fig. 5.

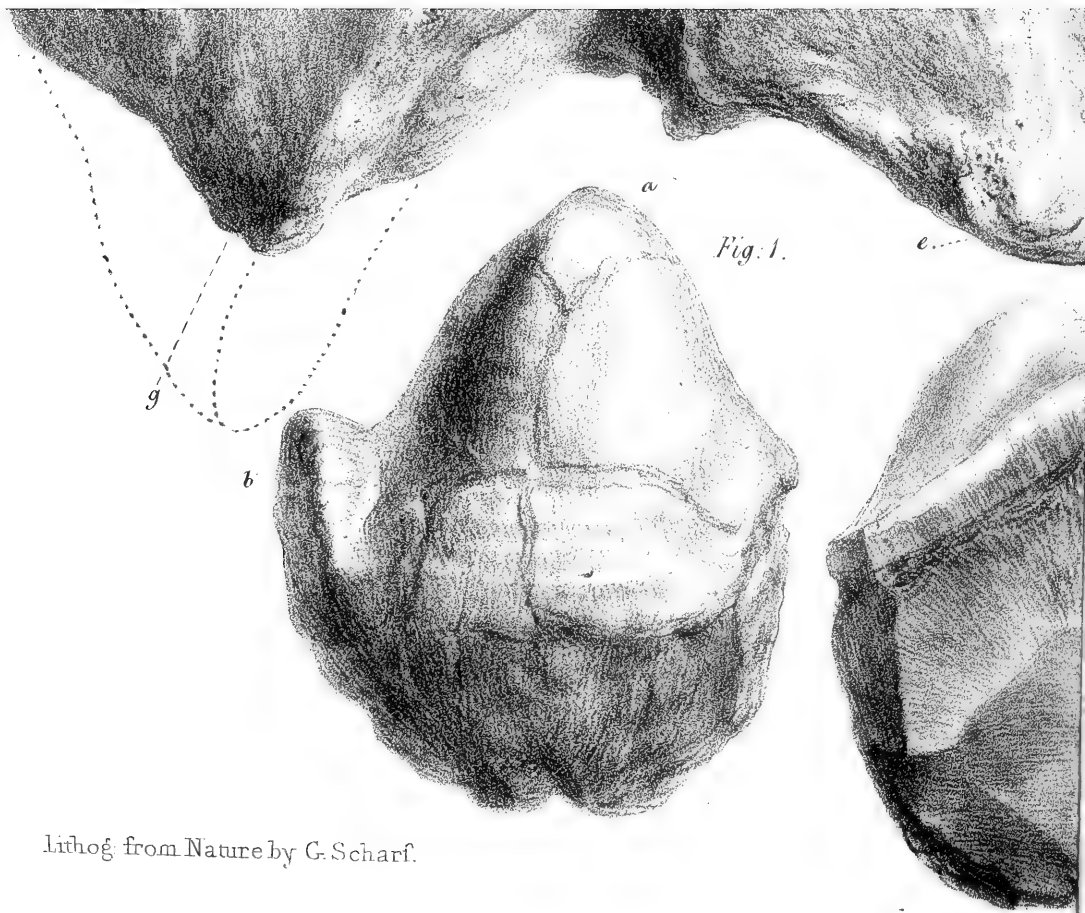


Lithog. from Nature by G. Scharf.

Thulmaude & Walton Lithographers.

Figs. 1, 1a. *Dinotherium Indicum*.
2, 2a. *Dinotherium Giganteum*.

Figs. 3, 3a, 4, 4a. *Bramatherium Perimense*.
5. *Camelopardalis Sivalensis*.
(Natural Size)



Lithog. from Nature by G. Scharf.

IV. TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

I. *On the BOULDER FORMATION and on DILUVIAL SCRATCHES in DENMARK and part of SWEDEN.* By G. FORCHHAMMER.

(Continued from page 272.)

Theories of the Boulder Formation.

ON considering the two theories that have been proposed to explain the phenomena of the formation and transport of erratic blocks, those, namely, of Agassiz and Sefström, it is manifest at the first outset, that neither of them can be applied in the case of Denmark, where these masses of drifted material are spread over thousands of square miles of nearly level country.

On the one hand the theory of Agassiz is inadmissible because of the manifest relation of our drift with the broken coral reefs, the newest of the cretaceous rocks, and also because the fossils distributed throughout the whole, and more especially in the brown-coal formation, indicate a climate like that of the Mediterranean at the present day. But this glacial theory is yet further opposed by the appearance of stratification, manifest everywhere, proving the deposition to have gone on under water, and also by the vast abundance of fragments of cretaceous rock accompanying the erratic blocks, fragments which could not have been brought down by glaciers from the northern mountains; since not only is it the case that no such formations now exist there, but there is also no indication whatever of their ever having been deposited. The innumerable disturbances which have gone on during the deposit of our boulder formation, and the fact that the beds enclose so many fragments of Arragonite distributed through the elevated masses, and requiring for their formation the existence of an elevated temperature, is also opposed to this glacial theory.

And if giving up this theory in its simple and original sense, the idea of Hausmann, Lyell, and others concerning the agency of icebergs and floating glaciers should be suggested, as explaining the appearances in question, it must be remembered that in the case of Denmark, the drift together with the thick beds of sand and

clay, the whole the produce of high northern latitudes, must have formed a series of successive deposits on the bed of an ocean. The fossils of the brown coal, the masses of cretaceous rock, the thick argillaceous layers of the boulder clay, are all opposed to the possibility of such an idea, since they all appear on the other hand to have been derived from the immediate neighbourhood, and in no case to have been transported from a distance. The littoral character of the boulder sand is also very clearly indicated by its fossils, whereas icebergs are transported only in deep water, while the stratification of the boulder sand and the relations of the rolled blocks it contains with those of the boulder clay are not less opposed to the admissibility of this theory.

The theory of Sefström agrees no better with the phenomena of the boulder clay as observed in Denmark than that of Agassiz. The mere length of time required is indeed a sufficient objection to the notion of a single deluge, for it is not to be imagined that a flood could last throughout the whole tertiary period. The necessity of the former existence of an almost tropical climate in which the cretaceous coral reefs might be formed, afterwards of a Mediterranean climate for the brown coal, and then finally the fact of a deposit having gone on in a deep northern sea, in which the *Cyprina* clay might be formed, and this deep sea gradually changing to shallow water over sand-banks in the same sea, are quite incompatible with the conditions required for this diluvial theory.

But if an universal deluge cannot have been the cause of our Danish *Aosar*, neither can it explain those of Sweden. I hope, however, to be able to show that a partial flood has produced important results during the deposit of the newest part of the boulder formation, but this flood was not immediately connected with the cause of the scratches and furrows on the rocks of the Scandinavian mountains.

The theory of Agassiz, according to which the diluvial scratches were produced by the movement of great glaciers, finds but little support when applied to the phenomena of the earth's surface in Northern Europe, and almost all who have examined the appearances in those countries seem rather to prefer the idea of transport by the agency of water, even if they do not altogether agree with the theory of Sefström. The phenomena of erratic blocks as they are observed in Scandinavia have indeed been so often described, and their analogies with those of Switzerland so frequently pointed out, that I have little to add on this head. The level rocks, or crags, called *Heller*, are ground down and partially polished on their inclined side (in Sweden this is generally on the north side), and on this side are seen occasionally broad well-marked furrows, and yet more commonly fine parallel scratches. On the whole the furrows and scratches are in the same direction, and the furrows are besides very often striated. In point of dimensions the furrows are about two feet long and from eight to ten inches deep, the scratches being seldom more than a line or two in depth, but the two sets of markings pass by insensible gradations one into

the other. In these points there seems no essential difference between the Scandinavian and the Swiss phenomena, but it appears to me as if the regularity in the boundary of the rocks thus acted upon, at least so far as regards the extent of this regularity, is peculiar to Scandinavia. The one side of the scratched rocks (called by Sefström the *lee-side*) is here always more or less decidedly perpendicular, while the other (the *stoss-seite* of that geologist, a phrase intimating that this side has been exposed to the *pushing* forward of the drift) is always a very gradual incline.* The perpendicular side of the scratched rocks is at right angles to the direction of the scratches.

If now we suppose, as is most probable, that the material of which the *Aosar* are made up, consists of the fragments broken off from the rocks now scratched and furrowed, it is not easy to imagine how a flood powerful enough to tear away with such extreme violence so large a quantity of rock, could at the same time deposit the broken fragments amongst the very rocks destroyed. But the *Aosar* are, in point of fact, not at all rare in the neighbourhood of scratched rocks, upon which indeed Sefström himself has found these heaps; and if it should be suggested that sometimes, under the shelter of a hard rock, they might occasionally be deposited, it must be remembered that they are in fact far too widely extended throughout Sweden for such an explanation to suffice. This very circumstance shows that the cause of the scratching of the rocks and the deposit of hillocks of gravel and sand cannot have been universal, but must have been, on the other hand, the result of innumerable separate disturbances. Sefström assumes that the course of his great flood of erratic blocks was from north to south, his proof of this resting partly on the relations of the *stoss-* and *lee-side*, and partly on the relations of the so-called normal and abnormal, principal and collateral scratches; but it seems to me that this proof is imperfect, and that the phenomena are not fairly judged of, since according to this idea the normal striæ should only be sought for on the highest of the Norwegian mountains; and unless we admit that the side towards the north has been denuded of many feet, nay of many fathoms, of rock, we cannot make it appear probable that the movement of the flood was not directly opposite to that north to south direction assumed.

In approaching the Swedish coast of the Cattegat from the sea, we at first only observe, as it were, pinnacles of rock rising above the waves. As we advance towards the land, however, small islands appear, and these become larger and more numerous near shore, their vertical side being seaward. Now to me these islands present a perfect analogy with the intersected and furrowed rocks

* Sefström must, it would seem, imagine that the country was originally everywhere terminated by a perpendicular cliff, (now the *lee-side*,) while the stony flood has cut off on the other side every sharp projection, leaving them on the *lee-side* unaltered. But it is hardly to be believed that any kind of temporary deluge can have cut off such enormous slices from a rock so hard.

of the interior of Scandinavia; and the vertical face of their cliff, being directed as it is towards that side most exposed to the beating of the waves, is a perfectly universal phenomenon common to all hard mountain masses, and is exhibited every where on the Danish coast, in the Orkneys, and elsewhere, while in bays and towards sheltered parts there is a more gradual incline.

Southwards from Gothenborg the road runs for many miles through a tract which is exactly a repetition of this condition, and which I consider has been formerly the sea bottom, exposed for centuries or rather thousands of years to the beating of the waves, but at length has become, at least partially, converted into arable land. Here, however, the rocks are so closely shorn as it were, and so denuded and polished, that one might suppose the action of the waves to have only lately ceased, and it is only here and there that some sorry plant has been able to root itself in the clefts of the rocks. It was in Gothenborg that I first had the opportunity of studying minutely the scratches on these rocks, and any one who could examine them and compare them with those of Göthaelv and others of the neighbourhood of Gothenborg, would declare at once that all of them were in like manner raised sea bottoms of similar origin. The shells, indeed, of species at present inhabiting the Cattegat, are found in the blue clay of the Gothenborg valley, and can be followed as far in the valley of Göthaelv as the granitic barrier over which the Falls of Trollhøtten are poured, where beds of them were discovered a few years ago.

These almost naked rocks of the neighbourhood of Gothenborg are every where covered with furrows and scratches, the direction of which I found to be about compass east and west, the variation not being greater than about 10° on each side of these bearings. I was also fortunate enough to find one large block, measuring between 100 and 150 cubic feet still lying there; it was much rounded, and a deep and broad furrow traversed it towards the west, which was continued towards the east on a much smaller scale. It was clearly an instance of a block arrested on its way and left behind by the flood, having performed only a part of its intended journey. *

Quitting the vicinity of Gothenborg, we by no means lose sight of the phenomena of scratched and furrowed rocks, which, indeed, are traceable in the valley of Göthaelv as far as Trollhøtten, and are distributed over the whole of the great central plain of Sweden. Here, however, we everywhere see marks of comparatively recent elevation from beneath the sea, but there may be observed a gradual change in the material thus transported eastward; the

* I might also here mention another phenomenon which has some, if not such immediate, reference to these scratches and furrows. A large furrow that had been commenced was stopped in the middle by a great mass of stone firmly jammed in the rock, and the furrow was continued on the upper part of the stone about three feet above its former level. It was manifestly a stone detached and elevated by a disturbance, and, if the whole had not undergone elevation, it would have been at last slowly carried away towards the east.

rocks which are naked near the coast gradually, as we advance inland, becoming clothed with vegetation, the number of loose fragments of rock increasing and the proportion of scratches upon them diminishing in about the same ratio. I am of opinion that these phenomena bear some relation to one another, for if the flood had lasted but for a short time, it would not have carried away the stones or left such traces of its action upon the rocks. I think, therefore, we may conclude that the rate of elevation was more rapid formerly in Scandinavia than in later times.

We must now consider whence were derived the numerous erratic blocks deposited in the boulder formation, since the action of water is sufficient to account both for the inclined and vertical face of the rock, although it in no way explains the scratches, except they were produced by the mere advance of hard heavy bodies, such as fragments of rock pushed on by water.

If we consider the way in which waves break upon a shore, we shall perceive that the crown of the wave falls over, and that the whole strength of the wave is, so to speak, concentrated in the upper part of it*: the principal materials driven forward by the waves, however, do not consist of fragments broken off by this violent beating upon the parent rock, but rather of vast masses of detritus, which still remains in the interior of Sweden, where neither scratched nor furrowed rocks occur, and the masses of which are in all probability partly the result of some early and violent disturbance, assisted perhaps by more recent disruptions and earthquakes, as in the neighbourhood of Gothenborg, aided no doubt partly by the splitting and transporting power of frost.

Some peculiarities of the scratched rocks, however, yet remain to be explained, and among the first of these is the fact that the broad furrows are also scratched, since it would seem that greater pressure was required for the finer scratches than one could obtain with the smaller stones. It is also difficult to understand the parallelism of deep and fine scratches upon a rock, since even if the differences in the direction of the waves as compared with the main direction is as nothing in the case of the larger and heavier stones, this cannot be the case also with the smaller ones; but I think all these difficulties vanish when we consider that the time of the occurrence of storms is generally winter, that the waves beaten against and broken by a resisting object, and frozen by the cold, become mixed up into a mass with broken fragments of rock, and that the icy crust thus formed of ice and gravel together produces a much greater effect than could be otherwise obtained. To

* As an instance of this might be quoted the case of the dykes on the west coast of Schleswig and Holstein, where injury is rarely done from without except when the waves wash over and carry away the lining of hard clay, and I have myself seen in the Faroe islands a large fragment of basaltic dolerite which the inhabitants informed me had been broken off from the solid rock by the action of the waves in winter, and lifted up upon the higher ground. If this part of the rock had been a ledge or shelf like those already described, the waves would have gradually driven this fragment forward.

this must be added the formation of ice floes by the uniting together of many icy fragments floating in the northern seas, the effects of which may be observed annually upon our coast, and which must have produced very important results even where the temperature was much less excessive than on the northern shore of Denmark and in Greenland.

If these explanations are accepted, it may be understood in what manner the material broken away from any spot may be collected into gravel-heaps, and deposited at no great distance.

One other phenomenon requires to be considered, and it is one which Böhlingk has alluded to, and which seems to me important. On the northern side of the Scandinavian mountain masses towards the White Sea, the vertical side of the rocks (the lee-side) is not towards the south, but in the contrary direction. It is here the beating of the waves of the Icy Sea that has produced the result in question, just as further to the south the East and North Sea have acted: and Keilhau has already remarked with regard to this, that one can now no longer assume, according to Sefström's theory, that the flood of stones was carried down from the North Sea; since to account for this appearance the point of starting must have been some spot in northern Norway. According to my view, we may understand also the reason why the scratches in the higher districts of Norway exhibit no regularity, but are directed to all parts of the compass. It was the first sea bottom that was elevated out of the great northern sea, and the beating of the waves would be first in one direction, and then, perhaps, suddenly in the contrary direction.

If we compare the direction of the scratches in those places where we can distinctly make them out, they are seen to have distinct relation to the direction of the line of coast bounding the neighbouring seas. This is manifest along the whole of the coast line of the Cattegat, and, indeed, throughout Sweden and Norway, and no one can help observing it with reference to the great bays between the two countries; so that it is only left to choose whether it is more probable that the movement took place from the land towards the bay, or from the bay towards the land. I have already stated my reasons for believing that the latter was the case.

I ought here to recognise the possibility that observations made with regard to other and far more extensive Scandinavian rocks may not confirm the view I have taken on this subject. But I have had the opportunity of studying very carefully several hundred separate instances of the phenomena we are considering, and am satisfied that in the middle of Sweden this view is satisfactory; and it only remains for me to show in what way a true flood of water has effectually acted in the formation of gravel and sand-hills. I have already explained this with regard to Denmark.

I have before shown, also, that the middle of Sweden everywhere offers indications of having been formerly covered by the ocean, and the more elevated land of Smaalund to the south has formerly existed as an island detached from northern Sweden by

a broad sound. That the Gulf of Bothnia has thus been united with the Cattegat, the open sea having reached to the gulf, is clear from the great *Aos* of Gefle and Stockholm, which contains marine fossils. But the Gulf of Bothnia has also been connected with the White Sea, where, in the neighbourhood of Uleaburg, a considerable depression towards its shores may be observed.* In the same way Norway and Sweden in former times were detached from Finland, a complete water communication existing from the White Sea through the Gulf of Bothnia, and the northern part of the Ost See to the Cattegat. This former communication may explain why the fossil remains of mollusca found on the west coast of Sweden and the north coast of Jutland have on the whole a more northern character than the species at present living in the Cattegat: but other causes besides these, and noticed by me elsewhere, must also be taken into consideration with reference to this subject. The gradual elevation of Scandinavia must from time to time have changed these relations, diminishing the communication of the Gulf of Bothnia with the sea till the separation was finally effected. Now the mass of water displaced by the elevation of so large a portion of the sea bottom, must necessarily endeavour to find an outlet, and escape either towards the north into the White Sea, or westward into the Cattegat. But in both these directions they would be opposed by a wall of granite, while the obstacles towards the south, consisting of soft, sandy, and scarcely consolidated rocks of the Silurian series, offered but little resistance, and were therefore broken through to form a passage. To effect this, however, a powerful current from north to south must have been in motion, and the deep indentation on the Prussian coast, which forms the Gulf of Königsberg, appears to mark this event.

The main stream must then have been deflected towards the south-west by the beating back of the waves, and has left indications of its passage in the island of Bornholm (which interfered with its progress) at a height of 250 feet above the present sea-level.† The continuation of the south-western current is marked by the separation effected between Rugen and Moen, and the deeply intersected bay of Lubeck.

The waves being reflected back from the coast, and acting again upon the advancing wave, the current must then have taken a diagonal direction towards the north, and a glance at the map will show that the gulf on the western side of the Cimbrian peninsula gradually takes a more northerly direction, till it loses itself in the so-called Kallövig. Now, I am aware that it is always dangerous to construct theories with regard to marine currents by examining

* I owe to General Lafrèn of Stockholm the information that communication by water was still kept up in time of floods, even so lately as at the commencement of the last century.

† Up to this height for instance is the granite floor of the island covered by a fat marly clay, full of fragments of all kinds of Silurian rocks just as they occur in Gothland and Oeland.

the outline of a coast on the map; but I am in a condition to prove, from well-marked local phenomena, the effects of the stream in the case before us; and it is worthy of notice, that the multitude of small Danish islands in the western part of the Ost See also consist of this same argillaceous matter, which is only found occasionally distributed in other parts of the country, and which I look upon as having existed originally as thick beds of clay of the boulder-clay formation, which have offered considerable resistance, and from which the sand has been removed, the clay being left behind. We find, for instance, the south of Iceland, with some exceptions, made up of this material; whereas in the north there are enormous masses of boulder-sand, and on the deeply-cut indentations between the hills, we find the boulder-clay with its layers of marl. On the north bank of the Gulf of Lubeck, in the district called Oldenburg, a chain of hills of this boulder-sand is seen parallel with the gulf as far as the interior of Holstein, and has formed admirable harbours, at the upper extremity of which are thick beds of the boulder-sand, while on the remaining part of the peninsula which slopes gently towards the west thinner strata of the same sand are observable. On the eastern peninsula of Jutland at Greenae, the boulder-clay on the other hand prevails; but towards the north, as in north Iceland, thick hilly masses of sand extend as far as the Liimfjord, while in the valleys the clay is again found. It is also only in those parts of Iceland, Fuhnen, and Jutland which extend far into the Cattegat, and where, as it seems, the waters of the Cattegat meet with those coming from the Ost See, that we find those rounded hills already described as being in all probability the result of powerful and opposing currents.

It is not determined, however, whether Denmark had already been elevated above the sea at the commencement of the period of these aqueous disturbances, and still less can it be distinctly made out whether man was then an inhabitant of the earth. All we know is, that no human remains, and not even any indications of land animals, have hitherto been found in the strata. This deluge is, therefore, not to be confounded with that of a later date, which, proceeding from the west sea, has destroyed a vast multitude of hillocks, the graves of the early inhabitants of the north. The mythical tales and legends of these people probably refer in some cases to this later catastrophe; since, if not Denmark, at least some parts of Sweden, may have been then inhabited. It appears, indeed, from phenomena observed at Bornholm, and already recorded, that the period of the last deposit of our boulder formation in the north, must have been from four to five thousand years ago.

D. T. A.

V. NOTICES OF NEW BOOKS.

- I. THE STRUCTURE AND DISTRIBUTION OF CORAL REEFS; *being the first Part of the Geology of the Voyage of the Beagle under the Command of Capt. Fitzroy, R.N. during the Years 1832 to 1836.* By CHARLES DARWIN, M.A., F.R.S., Naturalist to the Expedition. London, pp. 214. 1842.

MR. DARWIN, in addition to his journal of the voyage of the Beagle, has since published, with the approval of the Lords Commissioners of the Treasury, two volumes having reference to geological subjects — the results of investigations made during his expedition.

It is to be regretted, that the publication of these volumes was delayed in consequence of the ill health of the author, which long prevented the close attention necessary to prepare his observations for the press. We have reason to rejoice that the works themselves require no apology for the state in which they appear.

The object of the volume at present before us, is to describe in detail the general structure and the circumstances of formation of coral reefs, with the object of explaining and supporting certain views of the action of disturbing forces, assumed by the author to have produced elevations and depressions of the sea bottom, and in this way accounting for many geological phenomena in different parts of the world, and of various periods.

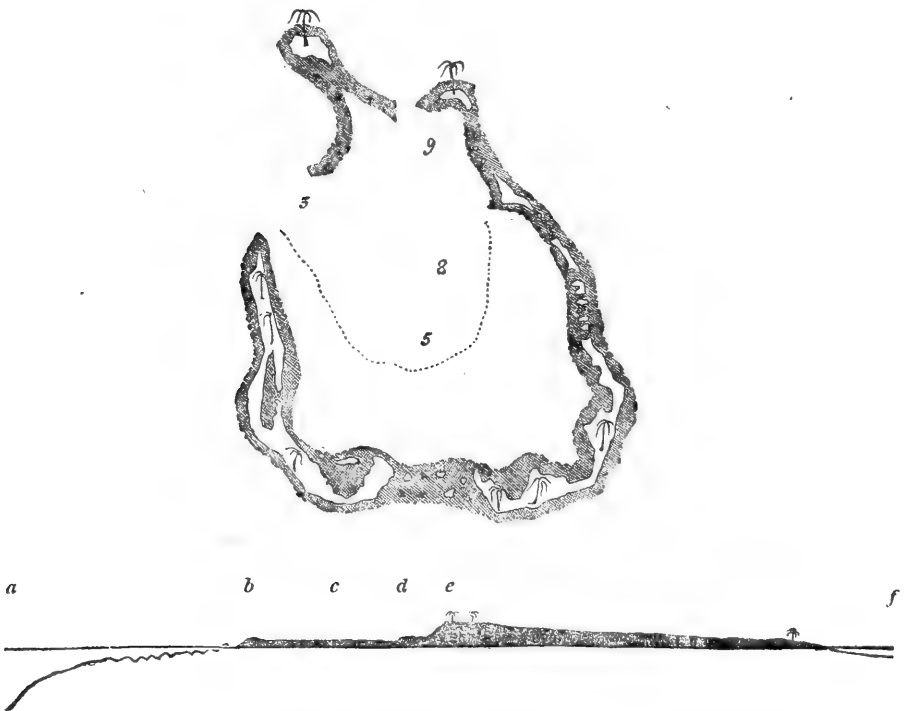
There are two great classes of coral-reefs, in one or the other of which the whole number may be included: those, namely, which exhibit near the surface no evidence of any solid rock from which they may have originated — *the barrier and atoll-formed reefs*, and those which are called *fringing-reefs* — where, owing to the nature of the slope and the vicinity of land, there can be no doubt as to the origin. The former class (including the lagoon islands) have attracted most attention, and offer the most striking phenomena, but both of them are extremely interesting.

The term "*atoll*" is used by the inhabitants of the islands in the Indian ocean to distinguish circular groups of coral islets sometimes called "Lagoon islands," a kind of salt-water lake or lagoon being often formed by a nearly continuous curved line of such reefs, only leaving one or two outlets. Barrier-reefs are little less marvellous in their structure than the atolls, the band of coral-reef sometimes forming a fringe of land, while sometimes

the existence of the reef is only indicated by a line of breakers, or a few small islets crowned with cocoa-nut trees ; and the reef in this case is at a considerable distance from a central island, which is not itself due to the labours of the coral polyp.

Fringing, or shore-reefs, differ from barrier-reefs in not having within them a broad channel of deep water, and in not lying so far from the shore. There are other kinds of reefs allied more or less nearly to one or the other [of these ; but they possess comparatively little interest. With respect to the origin of all these reefs, the great difficulty lies in explaining the foundation of the barrier and atoll-formed class, the fringing-reefs requiring little consideration.

KEELING ATOLL
(Chart and Vertical Section).



a. Sea level at low water ; depth 25 fathoms at 150 yards from the edge of the reef.

b. Outer edge of the flat part of the reef which dries at low water ; this edge is either a mound or consists of jagged rugged points.

c. A flat of coral rock covered at high water.

d. A projecting ledge of brecciated coral rock washed by the waves at high water.

e. Loose fragments of coral only reached by the sea during gales, and its upper part (6 to 12 feet high) clothed with vegetation.

f. Low water level of the lagoon.

Note. The dotted line in the chart marks the limit of shallow water.

Mr. Darwin has described every existing coral-reef in geographical order so far as he possessed information (with the exception

of some on the coast of Brazil), and has marked them on a map with colours distinguishing the different kinds. He has thus illustrated his own hypothesis on the subject, namely, that in both atolls and barrier-reefs, the foundation on which the coral was primarily attached has subsided, and that during this downward movement the reefs have grown upwards.

In order to give as distinct an idea as possible of the nature of the various kinds of coral reefs, a detailed account is given of one example characteristic of each class: the one selected as illustrating the subject of lagoon islands or "atolls," is Keeling Atoll, of which a reduced chart and vertical section are here appended.

The first thing to be observed with regard to the formation of these reefs, is, that the living coral animal does not endure exposure to the rays of the sun even for a very short time; and that consequently it is only at the outer edge, below the level of low-water, that the reef increases, or at least that those species to which the great mass of the reef is due can exist. The most abundant coral on this outer edge was found to be the *Porites*, which forms great irregularly rounded masses from four to eight feet broad, and little less in thickness; but a species of *Millepora* (*M. complanata*) is also able to resist the fury of the waves, and grows in thick vertical plates, intersecting each other at various angles, forming an extremely strong honey-combed mass, which generally affects a circular form, the marginal plates only being alive. The corals inhabiting the protected crevices on the outer reef, and those in the interior of the lagoon, are quite distinct, and belong to much more delicate varieties.

From soundings taken outside the reef at Keeling Atoll, the water was found to deepen gradually for a space between 100 and 200 yards wide, but beyond this, the sides plunge into the unfathomable ocean at an angle of 45° . To the depth of 10 or 12 fathoms, the bottom seems to be, invariably, living coral; between that depth and 20 fathoms, about an equal number of times sand and coral; but of twenty-five soundings at a greater depth than 25 fathoms, every one showed the bottom covered with sand, the sand consisting of finely pounded fragments of stony corals. At a distance of a mile and a quarter from the breakers no bottom was found with a line 7200 feet in length, proving that the submarine slope was greater than that of any volcanic cone.

The chart and section represent a ring partly formed of small islets on a coral reef, but if the part above the level (*c*), which is just covered at high water, were removed, there would be a simple reef which forms what is essentially the "atoll," and it encloses the lagoon on all sides, except at the northern end, where there are two open spaces. The reef varies in width from 250 to 500 yards; its surface is level, or very slightly inclined towards the lagoon, and the islets are first formed between 200 and 300 yards from its outer edge, through the accumulation of a pile of fragments thrown together by some unusually strong gale. They are afterwards increased by the addition of fragments on their outer

side, and the fragments become in time cemented into a solid mass, either made up of partially rounded fragments of corals of various sizes, or of calcareous sandstone, formed of a conglomerate in which the structure of the coral has often become much obscured or entirely lost.

The interior of the lagoon is the next subject that requires notice. In the case before us, about half its area consists of sediment and half of coral reefs; but the corals are very different from those on the outside, and are much more delicate. The reefs also are softer, and increase very rapidly.

The sediment from the deepest parts in the lagoon consists of calcareous sand, and large soft banks of similar mud have been observed in other atolls. When dry, this mud so closely resembles chalk, that it can scarcely be distinguished from that substance. Large shoals of fishes, and many other animals, are found to feed upon the branches of the living coral, and the excrement of these must constantly produce vast quantities of fine calcareous mud.

Judging from old charts of Keeling Atoll, the coral polyp has added much to the solid matter of the reef within a very moderate period, and the islets have also greatly increased; but so far is this from being the consequence of any general elevation of the land, that there is good evidence in proof of a small subsidence. At any rate, there is evidence here of a severe struggle in progress between the nicely balanced powers of land and water, and if left undisturbed, it is manifest, that though the islets may increase, and the lagoon become partly filled up, the general increase seawards, and even the final conversion of the lagoon into land, must necessarily be exceedingly slow.

Keeling Atoll may be taken as a fair example of the very numerous rings of coral reefs and coral islands in the Pacific and Indian Oceans; but many of them are much larger, and some, on the other hand, exceedingly small, and the nature of the submarine slope is, in the great majority of cases, similar. But although such is the case, generally, there are two exceptions so remarkable, that some special notice is due to them. These exceptions consist of the reefs which form the Maldivé Archipelago, and those which compose the great Chagos Bank.

The Maldivé Archipelago is 470 miles in length, with an average breadth of about 50 miles, the dimensions of the largest atoll are 88 miles by 20, and like the other larger ones, it is breached by numerous deep-water channels leading into the lagoon. The separate portions of the reef between these channels are, in many cases, especially in the more northern atolls, true ring-shaped atolls differing only from those in the open sea by being based on a shallow foundation, and grouped closely together on one large platform, with the marginal rings, forming the external atoll, arranged in a rudely formed circle. The lagoons in the atolls of this large group are from 10 to 20 fathoms deeper in the southern than in the northern part. It is observed in this

group, as in atolls generally, that the channel is generally situated on the side least exposed to the prevailing winds and the heavy seas.

It appears, with regard to the islets formed in this group, that some of them have come into existence as land only within a few years, while others are fast wearing away.

The great Chagos Bank is described by Capt. Moresby, as "a half-drowned atoll." Its longer axis is about 90 miles, and it is 70 miles in width across the broadest part. The central part consists of a level muddy flat between 40 and 50 fathoms deep, surrounded on all sides, with the exception of some breaches, by the steep edges of a set of sand-banks, varying in breadth from 5 to 12 miles, and rudely arranged in a circle. These banks are about 16 fathoms beneath the surface, and are bordered by a rim about a mile wide, consisting of smooth hard rock, and only about 5 or 10 fathoms beneath the surface. At the distance of half a mile from one part of this rim, no bottom was found with 190 fathoms, and off another point, none with 210 fathoms. The circumstances and cause of this submerged condition will require subsequent consideration.

Barrier reefs resemble, in general form of structure, the atoll reefs already described, but they inclose land and a lagoon channel instead of a lagoon or mere sheet of water. They are, however, sometimes of vast dimensions, one on the west coast of New Caledonia being 400 miles in length and upwards of eight leagues from the shore, and the Australian barrier extending along the eastern and north-eastern coast of that vast island for nearly a thousand miles, its average distance from the coast being between 20 and 30 miles. It is observed in many of these reefs that the coral banks rise from far greater depths than the animal can exist in, and the living corals form a comparatively small proportion of the whole amount.

Fringing or shore reefs differ from barrier reefs, as has been already stated, by the absence of a lagoon channel and by the close relation in their horizontal extension with the probable slope beneath the sea of the adjoining land. The reefs round the island of Mauritius offer a good example of this class; and here, as in barrier reefs, the reef is breached by a straight passage in front of every river and streamlet.*

Many islands are fringed by reefs of this kind, but where the sea deepens rapidly, the reefs are narrow, often not more than 50 or 100 yards wide, and they have a nearly smooth hard surface scarcely uncovered at low water, and without an interior shoal channel. Their dimensions and structure, in fact, depend entirely

* This peculiarity is explained afterwards by Mr. Darwin, and an account is given of other causes unfavourable to the advance of the coral animal, but it is stated that one of these fringing reefs, if elevated in a perfect condition above the level of the sea, ought to present the singular appearance of a broad dry moat within a low mound. This, however, would be greatly modified by the action of the sea during the elevation. (See p. 54.)

on the degree of inclination of the submarine slope, conjoined with the fact, that reef-building polyps can only exist at limited depths ; so that, where the sea is shallow, they lose their fringing character, and appear as separate and irregularly scattered patches, often of considerable area. These reefs also are generally higher and more perfect on the outer side, assuming the appearance of atolls, owing to the more vigorous growth of the coral where most exposed. They differ, however, from atolls in being less deep, in having their form less defined, and in being based on a shallow foundation.

Coral reefs are, for the most part, confined to the tropical seas, but extend as far as latitude $32^{\circ} 15'$ N. (at the Bermuda islands), and on the western shores of Australia to 29° S.

They do not seem to be influenced by the presence or absence of volcanic centres, but are totally absent in certain large districts within the tropical seas, and this apparently capricious distribution cannot be explained by any obvious causes. It seems beyond a doubt that the strongest and most massive corals flourish best where most exposed, while the presence of mud and sand, and of brackish or fresh water, is highly injurious. Different species abound in each of the different zones of depth, and in the case of some reefs there is no new material added above the lowest level which the water attains ; although, in others, the growth continues to high water mark. There is also a fact of singular interest and importance with regard to this point in the occasional submerged reefs in the Chagos Bank and elsewhere, which, in some instances, appear to have remained stationary for a very long period, and have no tendency to grow upwards. It is supposed by the author that, in their case the whole group of reefs has subsided some seven or eight fathoms, so that the species building near the surface were destroyed, and other species preferring this depth having succeeded to them, there is now little tendency to grow upwards. There is, at any rate, no equal tendency to grow upwards in all coral reefs, but their growth is unequal and dependent on circumstances.

There is no doubt that coral, under favourable conditions of growth, increases to an enormous extent, and very rapidly ; and although there are many instances on record of reefs which have not increased for many years, there are others telling a very different tale. The case of Matilda Atoll, described by Captain Beechey, is quoted as an example of this latter kind, this atoll having been converted in 34 years from being a reef of rocks into a lagoon island, 14 miles in length, with one of its sides covered nearly all the way with high trees. Some experiments are also mentioned in which it has been attempted to measure the rate of increase of different kinds of corals, and as one of the results of these is an instance of a growth two feet thick of coral accumulated on the copper bottom of a vessel in the course of twenty months.

Careful examination by soundings, together with such other observations as can be made on the subject, all unite in proving

that the reef-building coral animal does not generally live at a greater depth than about thirty fathoms, and this is not invalidated by the fact that living specimens have been found occasionally at much greater depth. The greatest depths at which the ordinary species grow appear to be those of the more northern parts of the Red Sea; but it is well known and has been already mentioned, that coral reefs occasionally exhibit a much greater thickness than this depth, although the lower portion is in such cases dead.

Having thus described the chief phenomena of coral reefs, and the circumstances of their growth, the author enters on the subject of the theory of the formation of the different classes of them, and shows the unsound nature of the theory most generally received, namely, that they are based on submarine craters, and also of the better theory of Chamisso, that the outer portions of a reef, being of the most vigorous growth, would first reach the surface. Neither of these theories, however, account for barrier reefs.

The cause that has given to atolls and barrier reefs their characteristic forms, is supposed by Mr. Darwin to have been the gradual subsidence of portions of the bed of the ocean over large areas, and is partly deduced from the consideration of these two circumstances, viz.: — first, that reef-building corals flourish only at limited depths, and, secondly, that vast areas are interspersed with coral reefs and coral islets, none of which rise to a greater height above the level of the sea than that attained by matter thrown up by the waves and winds. The foundation of each reef is assumed to have been rocky, but it cannot be thought probable that the broad summit of a mountain lies buried at the depth of a few fathoms beneath every atoll, with no one point of rock projecting above the surface over such a wide extent, and it is known that neither the flat disk of an abraded point, nor any other rocky foundation, is ever at the top of the reef. Besides the evidence in favour of a subsidence having taken place, derived from these and other considerations connected with the general appearance of the rocks, other evidence is adduced showing the probability of this view, which is then proved to explain in a very simple manner the ordinary phenomena of fringing reefs, barriers, and atolls, and some of the less regular forms of the two great classes of reefs, and it only remains to consider whether the actual distribution of coral reefs and their relative condition, agrees with such a theory of their formation. A chapter is added on this subject, and is accompanied by a coloured chart of all known coral reefs and islands, one colour being used to mark barrier reefs and atolls, and another distinguishing the fringing reefs which form a distinct type of structure. In this chart the difference between the atolls and barrier reefs is indicated by the tint; so that the one colour marks those districts in which it is supposed that subsidence has taken place at a slow but steady rate, allowing of the gradual accumulation of extensive coral reefs, while the other denotes that no such change of level to any sensible extent has taken place.

On examining the map with a view to determine the value of the theory of subsidence, it is at once seen, that while atolls and barrier reefs are generally near together, the fringing reefs are either distant from these, or in the exceptional cases, there is independent evidence of oscillations of level have taken place, subsidence having preceded the elevation of the latter, and elevation having preceded the subsidence of the former class.

There is however some direct evidence in the external appearance, of many of the atolls that subsidence has taken place; fissures formed by earthquakes and other recorded phenomena sufficiently proving that subterranean movement of this kind is in progress, while, on the other hand, with regard to the fringing reefs, they are all situated in districts where elevation of the surface would seem to be going on. The Society Isles, and the numerous islands and reefs of the Low Archipelago, are remarkable instances of subsidence, while the Sandwich Islands and the Philippines are equally striking examples of recent elevation. It is worthy of notice also, that in the vicinity of those areas of subsidence which are marked by the presence of coral reefs of the barrier and atoll kind, there is a total absence of volcanoes of recent action, while they abound in the districts where ringing reefs occur.

In conclusion, Mr. Darwin directs attention to the vast extent of the areas of subsidence and elevation on the earth's surface, whether as indicated by the existence of coral reefs, or by the plain evidence of observed appearances. It seems that in the space of ocean extending from the southern end of the Low Archipelago to the northern end of Marshall Archipelago, a length of 4500 miles, every island with one exception is atoll-formed. With regard to the district we are told : —

“ The eastern and western boundaries (the continents of Africa and S. America) are rising areas, the central spaces of the great Indian and Pacific oceans are mostly subsiding ; between them, north of Australia, lies the most broken land on the globe, and there the rising parts are surrounded and penetrated by areas of subsidence, so that the prevailing movements now in progress seem to accord with the actual states of surface of the great divisions of the world” Page 143.

Since, therefore, it appears, that while the surface of different kinds of coral reefs differs but little, the barrier reef or ring of coral surrounding an island becoming an atoll when the land disappears, and being distinguished from the fringing reef by the presence of a deep water lagoon or moat between the reef and the central expanse ; and since also the coral animal is found not to exist except at very limited depths compared with the actual depth of coral in the reefs, it results that —

“ There is no difficulty respecting the foundations on which fringing reefs are based, while with barrier reef and atolls there is a great apparent difficulty on this head ; — in barrier reefs, from the improbability of the rock of the coast or of banks of sediment extending in every instance so far seaward within the required depth ; and in atolls, from the immensity of the spaces over which they are interspersed, and the apparent necessity for believing that they are all supported on mountain summits, which, although rising very near to the sur-

face level of the sea; in no one instance emerge above it. To escape this latter most improbable admission, which implies the existence of submarine chains of mountains of almost the same height extending over areas of many thousand square miles, there is but one alternative, namely, the prolonged subsidence of the foundations on which the atolls were primarily based, together with the upward growth of the reef-constructing corals. On this view every difficulty vanishes; fringing reefs are thus converted in barrier reefs, and barrier reefs, when encircling islands, are thus converted into atolls the instant the last pinnacle of land sinks beneath the surface of the ocean.

“ Finally, when the two great types of structure — the barrier reefs and atolls on the one hand, and fringing-reefs on the other — are laid down in colours on the map, a magnificent and harmonious picture of the movements which the crust of the earth has within a late period undergone, is presented to us. We there see vast areas rising, with volcanic matter every now and then bursting forth through the vents or fissures with which they are traversed. We see other wide spaces slowly sinking without any volcanic outbursts, and we may feel sure that this sinking must have been immense in amount as well as in area, thus to have buried, over the broad face of the ocean, every one of those mountains above which atolls now stand, like monuments, marking the place of their former existence. Reflecting how powerful an agent with respect to denudation, and consequently to the nature and thickness of the deposits in accumulation, the sea must ever be when acting for prolonged periods on the land during either its slow emergence or subsidence: reflecting also on the final effects of these movements in the interchange of land and ocean-water on the climate of the earth, and on the distribution of organic beings, I may be permitted to hope, that the conclusions derived from the study of coral formations, originally attempted merely to explain their peculiar forms, may be thought worthy of the attention of geologists.” Pages 146—148.

D. T. A.

II. TRAVELS in NORTH AMERICA, *with Geological Observations on the UNITED STATES, CANADA, and NOVA SCOTIA.* By CHARLES LYELL, Esq. F. R. S. 2 Vols. 12mo. pp. 588. Map and Plates.

So far as regards geology, Mr. Lyell's work is eminently valuable, since it presents a connected view of the results of a large number of careful surveys of different parts of the Continent of North America, by means of a coloured geological map, in which the whole amount of information at present known on the subject of North American geology is incorporated. The importance of this as a means of simplifying and generalising the notions of English geologists with regard to the succession of strata on the other side of the Atlantic, it would be difficult to estimate too highly.

Mr. Lyell has also added much to the knowledge hitherto possessed on the subject of American geology by his own investigations in the field, and in the present notice we propose to point out in order the various geological matters touched on in the work before us, commencing with the older rocks, and so approaching last of all to those of newer date. The latter indeed, although perhaps the most important, we shall here scarcely allude to, because, having formed the subject of communications to the Geological Society, they either have been already or will be hereafter described in greater detail than even in the book itself

in the Proceedings of the Society, as published in the various numbers of this Journal.

The older Palæozoic or Silurian rocks of America appear to be, as in England, divisible into two series—the upper and lower, and Mr. Lyell has admitted in his coloured map seven sub-divisions, which are thus named:—

Upper Silurian	{	7. Hamilton group.
		6. Helderberg series.
		5. Onondaga salt group.
		4. Niagara and Clinton group.
Lower Silurian	{	3. Hudson river, Utica &c. group.
		2. Trenton, &c. limestone group.
		1. Potsdam sandstone, &c.

The Taconic system, named by Dr. Emmons from a chain of mountains which form a continuation of the green mountains of Vermont, and supposed to represent a group of formations more ancient than the Silurian, are not considered by Mr. Lyell as deserving an independent place among the rocks of the palæozoic series (vol. i. p. 246.).

(1) The Potsdam sandstones are chiefly developed in a narrow band on the south-eastern range of the great chain, extending south-west from the Vermont range and along the whole of that line; and they immediately succeed and overlie the granitic and gneissose rocks of Virginia, North Carolina, and Georgia. They are also found occupying a broader space on the banks of the great river St. Lawrence, between the north-eastern extremity of Lake Ontario and the city of Montreal; and here these most ancient of the fossiliferous rocks are loaded with the remains of *Lingula*, and a small placunoid shell nearly allied to a fossil also occurring in company with the *Lingula* in the lowest English silurian beds at Bwlth in Brecknockshire (ii. 157.) Beds of the same Lower Silurian date have also been traced on the banks of the Wisconsin river, a tributary of the Mississipi, and Captain Bayfield is inclined to consider a band of sandstone on the southern coast of Lake Superior as the equivalent of these oldest fossiliferous sandstones of Potsdam.

(2) The Trenton limestone is much more widely distributed in North America than the inferior beds of sandstone; but it appears difficult to separate it in some cases from the beds of the overlying Hudson river group (3)* (ii. 49). The “blue limestone,” as it is called, forming the hills and table lands around Cincinnati and elsewhere in Ohio, belongs to the upper part of the lower Silurian group, and abounds in organic remains, consisting chiefly of trilobites, brachiopodous shells, crinoidea, and many corals, the latter differing considerably in specific character from those in the

* The Hudson river group of Mr. Lyell includes a number of sandy and argillaceous slates containing Lower Silurian fossils, and separating in some cases the Trenton from the Niagara (Upper Silurian) limestones.

Lower Silurian strata of England (ii. 50.) With reference to the subject of Silurian fossils, Mr. Lyell takes occasion (i. 20., ii. 51.) to combat the notion that species were more cosmopolitan at this early period than they are at present.

(4) The Niagara and Clinton groups form the base of the North American Upper Silurian series, and are not represented on the eastern flanks of the Alleghanies, the uppermost Upper Silurian bed being there in immediate contact with the Hudson river series. A vast tract of country on the west of this chain is, however, occupied with a group consisting of these Niagara beds associated with (5) the Onondaga, and (6) the Helderberg series, but the sub-division is not here made out, although the different members are well seen in detail on the southern shore of Lake Ontario. The Hamilton group (7), the uppermost of the Upper Silurian series, is everywhere seen coming out from beneath the old red sandstone, which it seems to enclose as in a basin.

The Niagara limestone and shale correspond in their fossils with the Wenlock and Dudley limestone of England, and overlie the Clinton group, which might almost be looked upon as lower Silurian, but which it is thought better in the present state of palæozoic geology to class with the upper members of the series. The Onondaga salt group (5) is a remarkable formation of red and green argillaceous shale, marl, and shaly limestone, sometimes of great thickness, but partially developed; and the Helderberg series (6), although consisting in the State of New York of a number of distinct beds, passes so insensibly into the lower group towards the west, that, as we have already observed, no well-defined line of distinction can be drawn.

The Hamilton group (7) includes some shaly and slaty beds containing Ludlow fossils, and is widely distributed. It concludes the great Silurian series of North America, concerning which it may be remarked on the whole that with regard to the Alleghanies, the inferior or older beds range chiefly along the eastern or south-eastern flank, and are distinctly marked, while the newer groups of the same series, together with the Devonian and carboniferous formations, make their appearance as we proceed further westward. (ii. 9, 10.)

The rocks of the Devonian period—the old red sandstone series of North Britain and Herefordshire—are exhibited in a prominent and characteristic form, surrounding each of the great coal fields of the United States, and perhaps no where more strikingly than in the State of New York not far from Niagara. These beds here consist of olive-coloured slate and grey sandstone, containing occasionally impure coal, and in some sandstones (seen near Tioga) fragments of more than one species of *Holoptychius* have been obtained associated with a *Chelonichthys* of large dimensions. In Ohio, at the distance of 400 or 500 miles to the south-west, the author was struck by the extraordinary decrease in volume of the whole group, the absence of some formations, and the complete identity of those sets of strata that remained. In

the sandstones of this period many ripple marks are found, and the surface of the slabs is frequently covered with fucoidal impressions; but fossils appear to be rare.

It is chiefly with regard to strata of the carboniferous period that the investigations of Mr. Lyell in North American palæozoic geology must be considered important. The coal fields of the United States and the British possessions in Canada are beyond all comparison the most extensive and the most valuable of any at present known in the world; and the geological position of these deposits of vegetable matter, as well as the conditions under which they occur, are matters of very considerable importance to the future interests of the continent of America.

The great coal fields of the United States are the Appalachian, the Illinois, and the Michigan: those of the Canadas are on the eastern extremity of the colony, and occupy a great space in New Brunswick, Prince Edward's Island, Cape Breton, &c. A large proportion of the coal is anthracitic. It is not easy to do justice to these formations by the hasty sketch to which our limits necessarily confine us in this place; but some idea may be formed of their extent, when it is stated that the Appalachian coal fields extend for a distance of 720 miles from north-east to south-west with a width in some places amounting to 180 miles*; that the Illinois basin is not much inferior in dimensions to the whole of England; that the Michigan coal fields and the coal fields of Canada are also of very considerable dimensions; and that the thickness of the seams of fossil vegetable matter in some instances exceeds even that of the Staffordshire coal, amounting at the Lehigh summit mine (where the usually intervening shales and grit have thinned out) to one mass of fifty feet without any greater interpolated matter than two thin layers of clay. In some places this vast bed is quarried in the open air; but in others, where the coal is accessible to a degree scarcely to be imagined by strangers to the conditions of the country, the time has not yet arrived when the value of it as fuel is appreciated. (See vol. ii. p. 26, 27.)

One of the most remarkable facts, geologically, with reference to the carboniferous deposits of North America, is the great abundance and excellence of the anthracitic coal, met with more especially in the Alleghanies; but as Mr. Lyell's views and conclusions on this subject were communicated to the Geological Society shortly after his return to England, and have since been published in this Journal (see *antè*, p. 199.), it is not necessary here to dwell upon or recur to them; we rather prefer directing the attention of the reader to the coal fields of Nova Scotia as being a district in which our author has made most important additions to our knowledge of palæozoic geology, and as the subject offering the greatest amount of new matter for consideration.

The carboniferous group of formations, as developed in Nova Scotia, may be conveniently divided into three series, namely:—

* Its superficial area is calculated at 63,000 miles.

The upper, composed of sandstone and shale, with fossil plants.*

The middle, comprising the productive coal measures.

The lower, chiefly made up of red sandstone and red marl with subordinate beds of gypsum and limestone.

Concerning the lower series, which extends to the island of Newfoundland (where, however, the productive coal measures hardly reach), its position was not understood at the time of Mr. Lyell's departure for America; and from the peculiar character of its rocks and the abundance of gypsum it contains, it was supposed to overlie rather than underlie the true carboniferous rocks. Immediately after his return to England, our author communicated to the Geological Society his opinion that the whole group was a true lower member of the carboniferous series, and this opinion is fully borne out by the subsequent careful observations of Mr. Dawson already recorded in the pages of this volume (*antè*, p. 26.), and admitted by Mr. Brown (*ibid.* p. 23), and Mr. Logan, although, according to Dr. Gesner, there is still a want of such evidence as is satisfactory to him. The determination of this point is of very great importance in working out the geology of North-eastern America; and the similarity now known to exist between some of the fossils from beds above the carboniferous series and those at the very bottom of that series, together with some obscurity in the sections in a very difficult country, render it advisable to quote in this place the heads of the evidence on which Mr. Lyell's conclusions are founded. (vol. ii. p. 204.)

The first argument offered in the work before us is, that the rocks of what we may safely call the, gypsiferous formation, in Nova Scotia and Prince Edward's Island, always make their appearance nearer to the region occupied by the older rocks, whether Silurian or Metamorphic, and also that they are, on the whole, more disturbed than the coal measures. In attestation of this point, sections are referred to on the East River, and the Minudie, and also near Windsor, the rocks in the latter case being fossiliferous, and their evidence therefore of greater value.

In the cliffs near this town, Windsor and in the estuary of the Shubenacadie, these strata are very greatly disturbed and thrown into folds, part of which are tilted at considerable angles, while the rocks are fissured in the direction of their strike and shifted vertically. It would appear that there are no indications of the true coal measures having partaken of these disturbances, so that on both these grounds, and also from the probable continuation of the dip observed near the Minudie already referred to, the evidence all points to the same conclusion with regard to the age of the rocks in question.

The Albion mines near Pictou are remarkable for the great thickness of the coal worked there (estimated at thirteen yards). To the south of this district, Mr. Logan and other geologists have, it

* These uppermost beds, as they occur in Nova Scotia, are described by Mr. Dawson in the present number of the Journal. (See *antè*, p. 322.)

would seem, distinctly made out an underlying group of red sandstones and marine limestones, some of the latter beds having an oolitic structure, and the former being associated with abundance of redmarl. Mr. Lyell also states, as a second argument in favour of his view of the age of the gypsiferous beds, that he found most of the fossils of the limestones of Pictou to agree with shells and corals obtained by him in the limestones near Windsor, and in those of the Shubenacadie accompanying the principal masses of gypsum; while in these same limestones he found an intimate association between strata containing carboniferous fossils, masses of gypsum, and coal grits with *Sigillaria* and *Lepidodendron*, but no seams of pure coal. It appears also, in conclusion, that although overlying the coal measures there is a formation of red sandstone, generally without fossils, and often unconformable with the lower beds, there are no great masses of gypsum or beds of marine limestone associated with it, and nothing in fact that can identify these with the gypsiferous beds already described. There seems, therefore, little doubt that Mr. Lyell's views, coinciding as they do with those of Mr. Dawson, Mr. Brown, Mr. Logan, and other careful observers, are correct, and that the peculiar appearance and the minerals characteristic of the newest palaeozoic or oldest secondary groups in the old continents are in North America found in beds of a much more ancient date, and correspond with the lowest carboniferous slates of England and Europe, the beds of marine limestone in America being the imperfect representations of our carboniferous limestone.

It is the middle of the three principal groups of carboniferous rocks which in North America contains the productive coal measures. Confining ourselves chiefly to their appearance in Nova Scotia, we find them there developed to a vast extent, and the whole series is admirably exhibited on the banks of the South Joggins River, near Minudie, a locality otherwise remarkable in a geological sense, on account of the presence of numerous fossil trees embedded in an upright posture, and at several different levels. Mr. Lyell's attention had been drawn to the circumstances of these fossil trees by Dr. Gesner, and he was naturally desirous of satisfying himself with regard to so very singular a phenomenon. We extract portions of Mr. Lyell's account of his visit to Minudie having reference to the subject of these fossil trees.

From Minudie a range of perpendicular cliffs extends in a south-westerly direction along the southern shore of what is called the Chignecto Channel. The general dip of the bed is southerly, and the lowest strata near Minudie consist of beds of red sandstone, with some limestone and gypsum. The section is then obscure for about three miles, and then still further towards the south there comes in a vast series of newer and conformable beds (the productive coal measures), amongst which the upright trees occur; the same series continues many miles further to the south.

If we assign a thickness of four or five miles to this regular succession of carboniferous strata which must have been originally quite horizontal, our estimate will probably be rather under than over the mark. Where the section in the cliff is first well exhibited, we find about 44 feet of blue grit affording an

excellent grindstone, and about a mile further to the south, at a distance of about six miles from Minudie, the first of the upright trees appears. Then follows a series of coal-bearing strata, containing about nineteen seams of coal, occupying a range of coast about two miles long. At low tide a horizontal section of these beds is seen on the beach, and their edges in the vertical precipices.

The beds through which erect trees or rather the trunks of trees placed at right angles to the planes of stratification are traceable, have a thickness of about 2500 feet, and no deception can arise from the repetition of the same beds owing to shifts or faults, the section being unbroken, and the rocks with the exception of their dip quite undisturbed. In the first of these upright trees which I saw, no part of the original plant is preserved, except the bark, which forms a tube of pure bituminous coal, filled with sand clay and other deposits, now forming a solid internal cylinder without traces of organic structure. The bark is a quarter of an inch thick, marked externally with irregular longitudinal ridges and furrows, without leaf-scars, and therefore not resembling the regular flutings of *Sigillaria*, but agreeing exactly with the description of those vertical trees which are found at Dixonfold, on the Bolton railway, of which Messrs. Hawkshaw and Bowman have given an excellent account in the Proceedings of the Geological Society of London.* On comparing Mr. Hawkshaw's drawings of the British fossils, in the library of the Geological Society, as well as a specimen of one of the Dixonfold trees presented by him to their museum, with portions of the bark brought by me from Nova Scotia, I have no hesitation in declaring them to be identical.

The diameter of the tree was 14 inches at the top and 16 inches at the bottom, its height 5 feet 8 inches, and the strata in the interior consisted of a series entirely different from those on the outside.

Mr. Bowman has explained in the Manchester Transactions the causes of the frequent want of correspondence in the strata enclosing a buried tree, and the layers of mud and sand accumulated in the interior, which vary according to the more or less turbid state of the water at the periods when the trunk decayed and became hollow, and according to the height to which it was prolonged upwards in the air or water after it began to be imbedded externally in sediment, and various other accidents. It is not uncommon to observe in Nova Scotia, as in England, that the layers of matter in the inside are fewer than those without. Thus, a "pipe" or cylinder of pure white sandstone, representing the interior of a fossil tree, will sometimes intersect numerous alternations of shale and sandstone. In some of the layers in the inside of the trunk, I saw leaves of ferns and fragments of plants which had fallen in together with the sediment.

Continuing my survey, I found the second of the erect trees separated from the first by a considerable mass of shale and sandstone. This second trunk was about 9 feet in length, traversing various strata, and cut off at the top by a layer of clay 2 feet thick, on which rested a seam of coal 1 foot thick. This coal formed a foundation on which stood two large trees, about 5 yards apart, each about $2\frac{1}{2}$ feet in diameter and 14 feet long, both enlarging downwards, and one of them bulging considerably at the base. The beds through which they pass consist of shale and sandstone. The cliff was too precipitous to allow me to discover any commencement of roots, but the bottom of the trunks seemed to touch the subjacent coal. Above these trees were beds of bituminous shale and clays with *Stigmara*, 10 feet thick, on which rested another bed of coal 1 foot thick, and this coal supported two trees, each 11 feet high, and 60 yards apart. They appeared to have grown on the coal. One of these, about 2 feet in diameter, preserved nearly the same size from top to bottom, while the other, which was about 14 inches in diameter at the top, enlarged visibly at the base. The irregular furrows of the bark were an inch and half one from the other. The tops of these trees were cut off by a bed of clay, on which rested the main seam of the South Joggins coal, 4 feet thick, above which is another succession

* Vol. iii. pp. 139. 270.

of strata, very similar to those already described, with occasional thin seams of coal, and with vertical trees at five or six different levels.

I observed in all at least seventeen of these upright trunks, but in no instance did I see any one of them intersecting a layer of coal, however thin, nor did I find any one of them terminating downwards in sandstone, but always in coal or shale. Their usual height was from 6 to 8 feet, but one which was more than 100 feet above the beach, and which I could not approach to measure, seemed to be 25 feet high, and 4 feet in diameter, with a considerable bulge at the base. They all appear to be of one species, the rugosities on the surface producing the effect of a rudely-fluted column, and they were placed very accurately at right angles to the planes of stratification. I found numerous flattened trunks of large *Sigillaria* with their flutings and leaf-scars in the shales, but none of them resembled the erect trees with their irregularly furrowed exterior.

Stigmaria are abundant in the argillaceous sandstones of these coal-measures, often with their leaves attached, and spreading regularly in all directions from the stem. It commonly happens here, as in Europe, that, when this plant occurs in sandstone, none of its leaf-like processes (or rootlets?) are attached, but I saw one remarkable exception in strata of micaceous sandstone, in which the stem was about 4 inches thick, and traversed obliquely several layers of fine white micaceous sandstone 2 feet in vertical thickness.

I have stated that I counted seventeen upright trees in the strata of the South Joggins, and I was assured by Dr. Gesner, and by residents at Minudie, that other and different individuals were exposed a few years ago; the action of the tides of the Bay of Fundi being so destructive as continually to undermine and sweep away the whole face of the cliffs, so that a new crop of fossils is laid open to view every three or four years. I saw the erect trees at more than ten distinct levels, one above the other; they extend over a space from two or three miles from north to south, and more than twice that distance from east to west, as I am informed by Dr. Gesner, who has explored the banks of streams intersecting this coal-field.

Many curious conclusions may be deduced from the facts above enumerated.

1st. The erect position of the trees, and their perpendicularity to the planes of stratification, imply that a thickness of several thousand feet of strata, now uniformly inclined at an angle of 24° , were deposited originally in a horizontal position. But for the existence of the upright trees it might have been conjectured, that the beds of sand and mud had been thrown down at first on a sloping bank, as sometimes happens in the case of gravel and coarse sand. But, if we are compelled to assume the original horizontality of beds 2500 feet thick, through which the erect trees are dispersed, we can hardly avoid extending the same inference to the greater part of the strata above and below them. It by no means follows that a sea four or five miles deep was filled up with sand and sediment. On the contrary, repeated subsidences, such as are required to explain the successive submergence of so many forests which grew one above the other, may have enabled this enormous accumulation of strata to have taken place in a sea of moderate depth.

Secondly. The evidence of the growth of more than ten forests of fossil trees superimposed one upon the other prepares us to admit more willingly the opinion, that the *Stigmaria* with its root-like processes was really the root of a terrestrial plant fossilised *in situ*. Yet, if we embrace this opinion, it follows that all the innumerable underclays with *Stigmaria* in North America and Europe, are indications of an equal number of soils, whether of dry land or freshwater marshes, which supported a growth of timber, and were then submerged. If this be true, and the conclusion seems inevitable, the phenomenon of the upright trees in Nova Scotia, marvellous as it may be, shrinks into insignificance by comparison.

At the same time, it is quite intelligible, that we should find hundreds of cases where the soil has remained with the roots fixed in their original matrix for one instance where the trunk has continued to stand erect after submergence. Many favourable circumstances must concur, to allow of such an exception to

the general rule. There must, for example, be an absence of waves and currents of sufficient strength to loosen and overturn the trees, and the water must be charged with sediment ready to envelope the plants before they have had time totally to decay. I have shown that on the coast of S. Carolina and Georgia the land sunk in modern times, and that buried trees are occasionally found in strata containing shells of recent species. The formation of low islands of sand off the shore, breaking the force of the Atlantic, has probably allowed many of these trees near the mouths of estuaries to continue erect under water, until they were silted up and preserved. Similar low islands and sandbanks skirt nearly the whole of the eastern coast of the United States, and may assist the geologist in explaining some of the phenomena of the Carboniferous period, especially the manner in which superficial beds of vegetable matter, as well as upright trees, escaped the denuding forces.

Thirdly. It has been objected to the theory which refers the origin of seams of pure coal to plants which grew on the exact spaces where we now find coal, that the surfaces of ancient continents and islands ought to undulate like those we now inhabit. Where, they ask, are the signs of hills and valleys, and those river-channels which cut through deltas? These apparent difficulties will, I think, be removed, if we reflect that the fossilisation of successive forests presupposes both the subsidence of the ground and the deposition of sediment going on simultaneously. If so, the accumulation of mud and sand furnishes us with the levelling power required, and, had there been extensive denudation capable of producing valleys, it could readily have swept away all the coal. In regard to ancient river-courses, the late Mr. Buddle often assured me, that he had in many places met with them in the coal-fields of the North of England, and he has given a detailed account of one which intersected a seam of coal in the Forest of Dean. Even in these cases, however, the general evenness of the surface is immediately restored by a new sinking of the delta, and the deposition of fresh sediment, so that the succeeding seam of coal has grown on as perfectly flat a surface as if there had been no partial destruction of the beds below.

If it be objected that, according to the analogy of recent subterranean movements, some areas ought to have sunk down at a more rapid rate than others, producing irregularities in the ancient level of the dry land, we reply, that there are abundant proofs in the arrangement of the carboniferous strata, that the amount of local subsidence was actually not uniform. Mr. Bowman has clearly pointed out, that the wedge-shaped or lenticular masses of sandstone and shale, which sometimes intervene between the upper and lower portions of a seam of coal, are the natural result of such inequalities in the downward movement. In those areas which sink so fast as to be submerged, the growth of terrestrial plants is suddenly arrested, and the depressed region becomes the receptacle of sediment, until its level is again raised. Then the growth of the former vegetation is resumed, and the result is, the intercalation of strata for a certain space between two beds of coal, which unite and become one, if they are followed to a certain distance in every direction. Vol. ii. pp. 179—193.

The continent of America is well known to exhibit but very few indications of rocks of the secondary period, or at any rate of the triassic and oolitic series. Still the lower beds are by no means wanting, and the red sandstone of Connecticut, although it has been referred by some geologists to the Permian system, and is, perhaps, to a certain extent, a passage bed, appears to be, on the whole, more properly referred to the trias, and must, at least for the present, be looked upon as of that age. This rock has long been celebrated for the impressions of footsteps of birds with which its slabs are in many places covered, and Mr. Lyell mentions that since these impressions were first announced by Professor Hitchcock in

1836, and referred by him to birds, he (the Professor) has observed above 2000 footprints, probably made by nearly thirty distinct species. (Vol. i. p. 254.) The beds of this age in Connecticut include a fine-grained slaty sandstone, black and bituminous, and about six feet thick, which alternates with a coarse conglomerate. Small fragments of fossil wood and a ripple-marked surface were observed in some of the strata near the fossil fish. The only other rocks considered to belong to the older secondary period in North America are the coal measures of Eastern Virginia referred by Professor W. B. Rogers to the Oolitic period, but concerning these Mr. Lyell does not offer an opinion.

Our author's views of the cretaceous rocks of America will be found fully expressed in the earlier pages of this volume (see *antè*, p. 55.), and the tertiary strata will be described in similar detail in the next number.

In addition to those accounts of descriptive geology which come properly under consideration in speaking of the succession of strata, Mr. Lyell's work also contains some interesting facts and observations on the subject of changes effected, in comparatively modern geological epochs, by means of causes now in action. The geographical and geological features of the great Falls of Niagara occupied, as might have been expected, a considerable portion of his attention. With regard to the origin of these Falls, and the rate of their recession, (for of the fact of their recession there is distinct proof), we also have some speculations which cannot fail to be viewed with considerable interest. The superficial covering of gravel, the presence of erratic blocks, and the existence of hornblende and syenitic rocks, polished, furrowed, and striated, as seen in the north of Europe and in Switzerland, are also described and referred to by the author, in the course of his various journeys and traverses in various parts of North America. Numerous localities, in addition to the well-known salt-lick of Kentucky, are mentioned, in which the remains of that singular animal the Mastodon have been met with, frequently indeed associated with materials which prove how very recent must have been the date of its existence, as a regular inhabitant of that part of the world. It appears that in some places near Niagara the bones are found associated with shells, all of existing species now common in the district, but buried in shell marl below the peat, and therefore agreeing in position with the large fossil elks of Ireland.

The extensive swamps of North America afford matter of consideration to the geologist, and Mr. Lyell gives (vol. i. p. 143.) an account in some detail of one of the largest of them, known as the Great Dismal Swamp. This singular expanse of soft and muddy quagmire extends forty miles from north to south, and is in some places twenty-five miles broad. It is at a higher level than the surrounding dry land, and, even in spite of its semi-fluid character, is about twelve feet higher in the middle than towards the margin. The conditions of existence of this swamp and its

spongy vegetable soil suggest to Mr. Lyell the possibility that we may in this way explain the manner in which vegetable matter has been accumulated to form coal.

The instances of drift and erratic blocks in North America, quoted by Mr. Lyell, are too numerous to recount. The most remarkable instance perhaps of their occurrence in great abundance is in Long Island, where excavations lately made have exposed the boulder clay to the depth of thirty feet, and in this case the blocks are, some of them, of very large size; one which is mentioned (although not the largest), measuring 13 feet long, 9 feet broad, and 5 feet thick. Beneath the ordinary boulder clay, there appears to exist a red drift, the detritus of the new red sandstone formation of New Jersey, and this mass is also sometimes of considerable thickness. The boulder formation of Long Island contains blocks of very different mineral character in different districts, but the source may in most cases be traced, at least with very considerable probability.

In the work before us, the geological facts and observations are narrated in the order in which they were noticed and made. We have endeavoured to place before the reader an account of the materials thus brought together, leaving out of view the thread of personal narrative on which the geology is strung, and hoping in this way to add to the usefulness of what we consider to be the great characteristic of the work, the geological map of North America which has been prepared for its illustration.

D. T. A.

III. *A History of the FOSSIL INSECTS in the Secondary rocks of ENGLAND, accompanied by a particular account of the Strata in which they occur, and of the circumstances connected with their preservation.* By the Rev. PETER BELLINGER BRODIE, M. A., F. G. S. 8vo. pp. 130. 11 Plates.

THE author of this work has been remarkably successful in the discovery of minute fossils, and is well known to geologists as having worked out points of detail, which by most people would be passed by unregarded. Dwelling for a time in the vale of Wardour, he there discovered in the Wealden beds of the Purbeck series, a curious genus of Isopodous Crustaceans (*Archæoniscus*), first described from these specimens in the *Annales des Sciences* by M. Milne Edwards, and also a bed actually loaded with fragments of fishes, and the small crustacean of the weald, called *Cypris*, but containing also the remains of insects. Afterwards, in the vale of Aylesbury, he observed a bed likewise containing remains of insects, and occupying the same geological horizon. Removing then to Gloucestershire, this indefatigable searcher after the infinitesimal in Palæontology very soon succeeded in obtaining from

the lias, both in its upper and lower members, a very large number of insect remains, chiefly, as in the Wealden, from calcareous beds, rarely more than a few inches in thickness, but remarkably persistent over districts comparatively extensive.* The result of these investigations is given in the volume now before us, the greater part of the text of which is occupied by a minute detail of sections, showing the position of the fossiliferous beds, containing insect remains, but which includes, in a number of very beautifully executed plates, accurate representations of nearly 170 specimens, selected from a much larger series, and illustrating every species that can be at all distinctly made out. The drawings and the entomological descriptions have been prepared by Mr. Westwood, and the introductory observations and explanations of the plates by that gentleman give considerable value to the work, and render it an important contribution to British Palæontology.

The insects now described from the British secondary formations consist of three groups, all of them belonging to what may be considered the middle secondary period, and characterising each one of the three great subdivisions of that period, — the Lias, the Oolites, and the Wealden. There is well known to exist a certain uniformity of character in the middle secondary fossils, and many interesting palæontological facts, some of which have been long recorded, render it probable, that in England the whole group of the middle secondary rocks was deposited at no great distance from dry land, clothed perhaps with vegetation, and certainly the habitation of many strange and hitherto little known animals. Some, at least, of those whose remains have been handed down to us, indicate, by their structure, that they fed on insects. That the remains of insects, therefore, should be found in beds of the period in question, in a fossil state, was antecedently probable, although the delicacy of such organic remains might render it unlikely that they should have been preserved, except locally, and under peculiarly favourable circumstances.

The analogies of the insects made known to us by the discoveries of Mr. Brodie with animals of the same class at present existing, is a point for which palæontologists were also to a certain extent prepared by the previous descriptions given of those from the upper Jurassic rocks of Solenhofen, where forms occur so strictly resembling existing species, that it is difficult, in the absence of perfect specimens, to distinguish between them. Mr. Westwood's remarks on this subject are interesting and valuable.

As many as 300 specimens of insects of various kinds from the lias were examined by Mr. Westwood, and of these considerably more than one third consisted either of beetles, for the most part rudely preserved, or of their elytra, nearly ninety of the specimens consisting of single elytra or the two elytra detached from the body.

* It is to Mr. Brodie also that Palæontologists are indebted for the discovery of other minute fossil bodies of great interest, especially the remains of fishes in the Silurian strata.

All these are small and ill defined ; and although it is difficult from such fragments to define the condition of the imago, it is evident that most of the species were not aquatic in their habits, many, on the contrary, belonging to lignivorous or herbivorous species, and some being evidently elaterideous, while others may be carabideous. There are in the collections examined two or three instances of legs, all of which seem to have belonged to the slender-footed family of grasshoppers ; and the collection also includes about thirty specimens of the detached abdomens of various beetles, all of comparatively small size, not more, in fact, than one third of an inch in length.

Of detached wings from the lias, there are about eighty specimens, including *Libellulidæ*, *Ephemeridæ*, *Hemærobiidæ*, *Panorpidæ* (?) together with others, distinguished by the arrangement of the wing veins, which are also found in the wealden rocks. On the whole, these insects of the lias resemble forms of ordinary occurrence and of temperate climes, more nearly, however, approaching those of North America than those of Europe.*

From the Stonesfield slate and other middle beds of the middle secondary period, the collection of insects described is not numerous, and the specimens, with a single exception (a portion of the wing of a very large neuropterous insect), consist of the elytra of beetles ; the perfect insects in these cases must have varied in length from half an inch to $1\frac{1}{2}$ inch, and some of the larger species were evidently lignivorous in their economy.

The remains of insects from the Wealden are, on the whole, the most interesting of the series, and the best defined in the collection, and they are considered by Mr. Westwood to afford a tolerably correct average indication of the state of insect life during the wealden period, so far as the series extends. As many as 74 figures of these are given in Mr. Brodie's work, selected from 239 specimens ; and the specimens figured belong to many different orders, among the chief of which are *Coleoptera*, *Orthoptera*, *Neuroptera*, *Hemiptera*, and *Diptera*.

The minute size of many of these specimens, especially amongst the *Diptera* and *Coleoptera*, is worthy of notice, as appearing to indicate a low temperature at the time of their existence, since it is well known that the lower the temperature, the smaller are the insects which inhabit a region ; and although this conclusion is not certain, and some individuals are preserved, which, judging from present insect life, must have been the inhabitants of a warm, if not a tropical climate (e. g. *Ricania* and some wings), still with these exceptions there seems nothing to warrant the supposition of a climate very different from that of our own country. On the

* A small collection, consisting chiefly of fragments of minute beetles, is especially alluded to as having been obtained from the supposed Triassic beds of Aust Cliff. The evidence, such as it is, obtained from the examination of these insects, does not warrant the supposition of any difference having obtained in the conditions of their existence.

contrary, we find species, such as the *Aphides*, which in the tropics are represented by other and much larger insects, associated with *Libellulæ* (dragon-flies) of gigantic size, and other species nearly allied to the almost equally voracious insect-feeding genera, *Panorpidæ*.

“It is scarcely to be supposed,” adds Mr. Westwood, “that a state of things could have existed in which we should find such a collection of insects as the Wealden series exhibits, without there being parts of the world inhabited by giant *Cicadæ*, immense beetles, locusts, and grasshoppers, with wings expanding little less than a foot, and other insects of the size at least of those in the present creation.”

The number of families and genera determined from the Wealden, so far as the condition of the specimens would allow, is very considerable. Thus there are 18 *Coleoptera*, 3 *Orthoptera*, 12 *Hemiptera*, 7 *Neuroptera*, and 13 *Diptera*; but some of the number are very imperfectly made out.

IV. KOSMOS. *Entwurf einer physischen Weltbeschreibung*.*
 Von ALEXANDER VON HUMBOLDT. Erster Band. Stuttgart
 und Tübingen. 1845. 8vo., pp. 494.

THIS first volume of a work under the title of “Cosmos” (or the Universe), vast and comprehensive in its object, and undertaken by that remarkable man who has made such important and valuable contributions to the scientific literature in Europe — Alexander von Humboldt — has been long expected on the continent, and naturally excites very considerable interest among a large class of persons who are carefully working out in detail one department of science, and are at the same time anxious to obtain the best and truest general views concerning the progress and present condition of other branches, and of the connection that may be traced amongst them. M. de Humboldt’s essay will be read and studied by such readers, and will no doubt be long quoted as a text-book even when the advance of knowledge and general views in science shall have rendered it out of date. Translations of it are, we know, preparing in our own and in the French language, and these will soon make the *Cosmos* familiar to all. Meanwhile, we will endeavour to give in a very few pages a general outline of the work, and more especially of that part of it which is technical to ourselves, as introducing the subject of Geology.

The volume now before us contains : — 1. Preliminary considerations concerning the extent and variety of the different kinds of enjoyment arising from the study of nature and the investigation of nature’s laws. 2. An account of the limits and the scientific

* Sketch of a physical description of the universe.

treatment of a physical description of cosmical phenomena; and 3. A general picture of nature; or, in other words, a complete sketch of these various cosmical phenomena. Of these three parts the first has long been written, and was delivered many years ago as an address on the opening of a public institution at Berlin; but has been added to and altered in some respects for the present work. The rest of the volume, although not without some apparent resemblance to a series of lectures delivered by the author in 1827-8, contains little that is not specially prepared for the present work.

As an example of the mode of treatment pursued by our author with reference to geological phenomena, we may here offer a quotation introduced after some observations on the important mutual bearing of certain remarkable facts made known by the careful study of physical astronomy: —

Just in the same way as in these astronomical conclusions, it is only by means of general views of cosmical phenomena that we are enabled to perceive the relation between the theory of the pendulum, so ingeniously worked out by Bessel, and the condition of the material substance of our planet in its interior—between the production of porphyritic rocks in lava currents on the flanks of an active volcanic mountain, and the masses of granite, porphyry, and serpentine which have been forced up from the deep recesses of the earth through the overlying stratified rocks, hardening, silicifying, dolomitising and crystallising them—between, in fact, the elevation of conical hills and small islands by the elastic force of modern volcanic action, and the formation of vast mountain chains and of whole continents, — a relation, be it observed, clearly proved by means of a series of admirably contrived observations made by one of the greatest of living geologists, Leopold von Buch. Such a protrusion of igneous rock, elevating at the same time the overlying horizontally deposited strata, accounts for the presence of the fossil remains of mollusca found by myself and M. Bonpland at the height of 14,000 feet above the sea, on the flanks of the Andes, allowing us to suppose that they have been placed where they now are by volcanic force lifting them up from their original position, and not requiring that the sea should ever have washed over them at their present altitude.

Volcanic agency, using this phrase in its most extended sense, I consider to be, whether upon the earth or on its satellite the moon, the reaction by which the material substances elaborated beneath the surface are lifted, from time to time, above the surface. Those, however, who are not acquainted with the experiments concerning the increase of temperature observed at increasing depths beneath the earth (experiments which render it probable that granite exists in a melted state at the depth of about twenty miles) can of course form no idea of the cause of numerous phenomena recently observed concerning the contemporaneity of volcanic eruptions and earthquakes over a vast extent of country, the uniformity of the temperature of warm mineral springs, or the difference of temperature of artesian wells sunk to different depths. But this knowledge of the internal temperature of the earth throws some glimmering of light upon the ancient history of our planet, for it shows the possibility of a former universal and tropical climate, the result of heat emanating perhaps from fissures in the recently hardened and oxydised crust of our globe. It thus reminds us of a condition in which the temperature of our atmosphere was dependent on the heat radiating from the planet itself outwards into space, rather than on the relation of the planet to a great central mass (the sun), whence alone it now obtains warmth.

Many indeed are the tropical productions, hidden and buried beneath the surface, but discovered by the geologist, in the colder regions of the earth: — coniferous trees, erect trunks of palms, tree ferns, the shells of Cephalopodous

molluscs, and the remains of fishes with rhomboidal enamelled scales are found in the ancient coal formations; colossal skeletons of crocodilian animals and the long-necked *Plesiosaurus*, together with various shells belonging to other groups of Cephalopoda, and the remains of Cycadæaceous plants occur in the rocks of the oolitic period; other not less strange and varied forms are met with in the chalk, some of them, however, approaching more nearly to existing species; while extensive masses of fossil remains of infusorial animalcules, whose history has been made known to us by the microscopical discoveries of Ehrenberg, are exhibited in the various beds of newer date, known as polishing slate, semi-opal, &c.; and the bones of the hyæna, the lion, and numerous elephantine pachyderms are strewn over the floors of caverns, or are covered up by the most recent deposits of mud and diluvium. In proportion as our knowledge of other natural phenomena becomes more complete, these marvellous productions cease to be mere objects of curiosity and wonder, and they become, as they deserve to be, the source of earnest and deep consideration. — pp. 26—28.

In his general sketch of cosmical phenomena, our author, as might perhaps be expected, devotes a considerable proportion of his space to a description of astral and planetary phenomena, and the meteorological discussions that arise out of such considerations. In passing thence to the actual crust of our globe, he alludes (p. 166.) to the calculations that have been made as to the extent of our knowledge on this subject derived from geological considerations, and also recurs to the question of subterranean temperature. After a somewhat detailed account of the determination of the form of the earth, its mass, and other physical characters, the subject of earthquakes and volcanic disturbances is introduced; and here the great and varied knowledge of the author on a subject of late but too little studied is admirably exemplified. We cannot, however, find space for any extended quotation, and without such the nature of the argument in this part could not be fairly judged of; but we may refer the reader who is interested in this subject to the original (see p. 210. *et seq.*), where he will find much important and some new information. The subject of gaseous eruptions and of cold and warm springs succeeds the consideration of the other more terrible marks of volcanic and deep-seated action, and a few remarks are added on mud volcanoes before proceeding to the consideration of the distribution of active volcanic centres on the earth's surface.

Passing on then to the more geological considerations relating to volcanic phenomena and igneous rocks generally, it becomes a matter of interest to the English geologist to learn the views of so well-informed a writer with regard to igneous geology. We make no apology therefore for quoting a page or two from this part of the work before us, and the more so since M. de Humboldt's views of the geology of fossiliferous rocks are not given in any detail, and need not detain us, offering nothing that is at all new to the English reader. The following account of granitic rocks will, we think, be read with some interest.

Granite and syenite are of very different geological ages, the date of formation of the granite penetrated by syenitic veins being more modern than that of the elevating disturbing force. The surface of insulated granitic masses of ellipsoidal shape, whether in the Hartz, in Mysore, or in Southern Peru, is

usually covered with innumerable detached blocks, probably owing to the contraction and cracking of an outer shell of granite while cooling.* In Northern Asia again, in the beautiful and romantic neighbourhood of the Kolivan Lake on the north-western flank of the Altai mountains, and also on the slope of the coast chain of Caracas, near las Trincheras, I have seen the granite in step-like terraces; this peculiar form being probably due to a similar contraction which has taken place deep in the recesses of the earth. Further towards the south, advancing from Lake Kolivan towards the limits of the Chinese province of Ili, the appearance of the igneous rocks, here quite unaccompanied by gneiss, is more striking than I have seen in any other part of the world. The granite, always comparatively flat and characterised by its tabular form, appears in the steppes, sometimes in small hemispherical hillocks from six to eight feet high, sometimes in projecting erupted masses, like walls of basalt appearing above the surface. At the cataracts of the Orinoco, as in the Fichtelgebirge and in Galicia, and between the southern lake and the high table land of Mexico (at Papagallo), I have seen granite in great flattened spherical masses, exhibiting, when broken, a concentric structure like basalt; and in the Irtysh valley (in Siberia) the granite for some miles overlies clayslates of an ancient date, and penetrates them in numerous small wedge-shaped veins from above. I have only quoted these isolated examples to show how universally the eruptive character is exhibited in a rock so widely distributed; and we find that just as in Siberia, in the instance last quoted, and in the department of Finisterre (Isle de Mihau) the granite rests upon slate, so in the mountains of Oisons (Fermonts), it covers the rocks of the Jura formation, and at Weinböhla, in Saxony, the cretaceous rocks which again themselves repose on syenite. In the Ural also (near Mursinsk), the granite contains cavities, and, as is the case with cavities and crevices in modern volcanic rocks, so here they are occupied by beautiful and perfect crystals, especially of beryl and topaz. — p. 261.

Having briefly alluded to the ordinary phenomena of the earth's structure, the metamorphic (next to the igneous rocks) supplying our author with the chief subjects for discussion, he proceeds to the consideration of the important problem as to whence were derived the materials of, and where were deposited the most ancient sedimentary rocks of our globe (p. 299.), and what form was assumed when dry land first appeared above the waters. "The result of investigations regarding the superficial relations of dry land is, that in the earliest, viz. in the Palæozoic periods as well as in the most ancient secondary periods, the uncovered surface which was clothed by land plants was limited to detached islands; that afterwards these islands were united with one another, and included many lakes along the deeply penetrating bays of the sea; and lastly, that when the mountain chains of the Pyrenees, the Apennines, and the Carpathians were elevated, therefore at the period of the older tertiary strata, vast continents, having nearly their present size, made their appearance. In the Silurian world, as well as during the period characterised by a profusion of *Cycadeæ*, and by gigantic Saurians, the amount of dry land from pole to pole was probably less than it is at present in the South Sea and the Indian Sea." (p. 302.) The consideration of this subject leads to a disquisition concerning the effect of the actual distribution of land and water on climate, and the general physical results of the actual configuration of the earth's surface at present;

* See von Buch's paper on this subject, translated in the first Number of this Journal, *antè*, p. 126.

and the volume closes with a review of the various subjects of ethnographical interest, suggested by the contemplation of man under various circumstances, as the chief inhabitant and modifying agent on the earth. With regard to this subject we cannot however do better than quote the concluding words of our author, where he observes that "while laws, whose mode of operation and whose nature may be in some measure known, govern the physical world, other laws of a different kind and far less manifest, regulate the phenomena of life in the organic world, and more especially with respect to the human race, so varied in aspect, endowed with such creative power, and gifted with the faculty of speech. A physical survey of natural phenomena indicates thus the verge of another and a higher condition, but it merely indicates it, and there at once stops." — p. 386.

D. T. A.

VI. MISCELLANEA.

I. *Account of certain Species of SILURIAN FOSSILS from HOBART'S TOWN, NEW SOUTH WALES.*

THE following are the results of the examination by M. de Verneuil of certain fossils collected from Mount Wellington, near Hobart's Town, New South Wales. The schistose sands and carboniferous limestones appearing among compact diorite in different points near Hobart's Town are often flattened by the enormous pressure they have undergone, and the shell is often gone and only represented by an imperfect cast.

Productus pustulosus (Phillips.) A species closely resembling *P. scabriculus* (Sow.), and identical with the species common in the mountain limestone of Yorkshire.

Spirifer very near *S. trigonalis*. It is extremely abundant in the collection, and attained a large size. It has five or six ribs on each side of the dorsal furrow.

Another species of *Spirifer* with dichotomous ribs.

Another species like *S. undulatus* (Sow.) with transverse striæ on the ribs. The ribs are larger and less numerous.

Spirifer oblatius (Sow.), or *Terebratulites lævigatus* (Schlotheim), like those of Visé in Belgium.

A very large smooth *Spirifer* with a depression on each side of the dorsal furrow between this furrow and the edge of the shell.

A large bivalve.

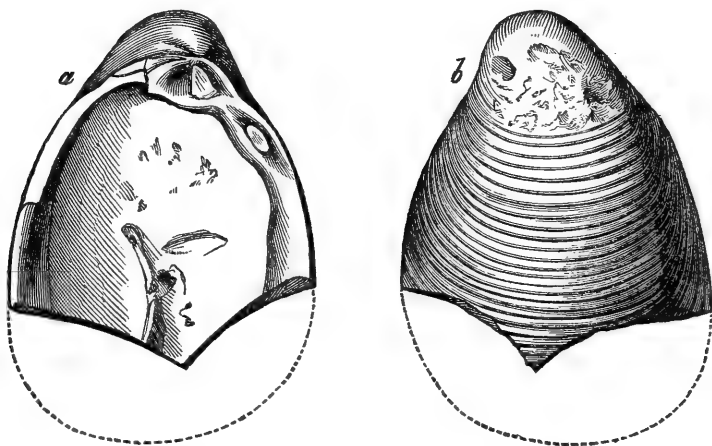
Large pectens belonging to a new species.

A new species of *Calamopora*.

The same species are found in Van Diemen's Land, and besides them are a great abundance of *Retepora*, *Cyathophyllum*, *Calamopora*, *Clypeaster*, and *Dentalium*, which are rarely met with in the neighbourhood of Mount Wellington. All these specimens were collected in the hills of Morambiji to the south of the Blue Mountains, and the beds containing them are partly covered as at Hobart's Town with recent lignites.

[Extracted from the *Voyage de la Bonite*. Geologie et Mineralogie, par M. E. Chevalier, p. 332.]

II. *Description of a New Species of CARDIUM from the Greensand of HALDEN HILL in DEVONSHIRE.*



Cardium concentricum. E. Forbes.

- a.* Under side of valve showing the hinge.
b. Back (one third linear dimensions.)

Cardium concentricum. C. testâ ovatâ, tumidâ, crassissimâ, in medio sulcis regularibus, subdistantibus, profundis, concentricis, sculptis; lateribus subcompressis, lævigatis; labro integro.

Length (if perfect), 5 inches.

Greatest breadth, $3\frac{8}{10}$ inches.

Height of valves, $2\frac{8}{10}$ inches.

This fine shell is described and figured from a single valve, (communicated by Mr. Austen), which, though imperfect, presents all the essential characters, and beautifully displays the greater part of the hinge, the cardinal and one of the lateral teeth. The shell is elongate and oval, tumid and compressed at the sides. The surface is marked by regular deep concentric striæ or narrow sulcations, with broad intervening spaces which are more or less flattened. Towards the sides the striæ become gradually obsolete, and the shell only marked by irregular lines of growth. There is a slight indication of an undulation or obsolete furrow, marking the division between the sulcated and smooth portions of the anal half of the shell. The internal margin is smooth. The beaks are slightly incurved. The nearest ally of this species is the *Cardium sphæroideum* of the Lower Greensand; of which, indeed, it may be considered representative.

III. ACCOUNT OF THE PRODUCE OF THE GOLD MINES OF RUSSIA, FROM 1830 TO 1842.

Years.	MINES BELONGING TO THE CROWN.			MINES BELONGING TO INDIVIDUALS.			Grand Total.
	Mines of Oural.	Mines of Siberia.	Total.	Mines of Oural.	Mines of Siberia.	Total.	
1830	Pounds, liv. sol. 147 31 67	Pounds, liv. sol. 0 25 1	Pounds, liv. sol. 148 16 68	Pounds, liv. sol. 199 33 42	Pounds, liv. sol. 4 22 40 $\frac{3}{4}$	Pounds, liv. sol. 204 15 82 $\frac{3}{4}$	Pounds, liv. sol. 352 32 54 $\frac{3}{4}$
1831	153 37 53	5 3 0	159 0 53	200 11 68 $\frac{3}{4}$	5 15 35 $\frac{3}{8}$	205 27 77 $\frac{3}{8}$	364 27 60 $\frac{3}{8}$
1832	162 22 41	5 39 82	168 22 27	200 6 48 $\frac{1}{2}$	15 37 49 $\frac{1}{2}$	216 4 2 $\frac{1}{2}$	384 26 29 $\frac{1}{2}$
1833	142 7 28	6 1 28	148 8 56	199 22 36	30 31 25 $\frac{3}{4}$	230 13 61 $\frac{3}{4}$	378 22 21 $\frac{3}{4}$
1834	138 6 27	11 36 38 $\frac{1}{2}$	150 2 65 $\frac{1}{2}$	171 14 92 $\frac{1}{2}$	53 21 50 $\frac{1}{4}$	224 36 46 $\frac{1}{4}$	374 39 16 $\frac{1}{4}$
1835	131 25 11	20 36 24 $\frac{1}{2}$	152 21 35 $\frac{1}{2}$	160 28 44	72 16 50 $\frac{3}{8}$	233 4 94 $\frac{3}{8}$	385 26 33 $\frac{1}{4}$
1836	128 27 84	20 24 81 $\frac{1}{4}$	149 12 69 $\frac{1}{4}$	164 9 4	84 19 20 $\frac{1}{4}$	248 28 24 $\frac{1}{4}$	398 0 94
1837	131 0 13	26 2 15 $\frac{1}{4}$	157 2 28 $\frac{1}{4}$	178 21 25	106 36 65 $\frac{1}{2}$	285 17 90 $\frac{1}{2}$	442 20 23
1838	131 34 80	27 37 93 $\frac{1}{4}$	159 32 77 $\frac{1}{4}$	168 12 4	165 8 50	333 20 54	493 13 35 $\frac{1}{4}$
1839	140 2 2	23 29 57	163 31 59	169 29 25 $\frac{1}{4}$	159 18 55 $\frac{1}{4}$	329 7 80 $\frac{1}{2}$	492 39 43 $\frac{1}{2}$
1840	134 4 79	32 33 40	166 38 23	164 11 78 $\frac{1}{2}$	216 22 81 $\frac{1}{2}$	380 34 64	547 32 87
1841	131 19 25	29 2 87 $\frac{1}{2}$	160 22 16 $\frac{1}{2}$	164 39 84 $\frac{1}{2}$	321 12 86 $\frac{1}{2}$	486 12 75	646 34 91 $\frac{1}{2}$
1842	130 12 24	37 32 64 $\frac{1}{2}$	168 4 88 $\frac{1}{2}$	162 3 86	578 4 33 $\frac{1}{8}$	740 7 23 $\frac{1}{8}$	908 12 15 $\frac{3}{8}$
Total	1,803 31 54	248 25 36 $\frac{5}{8}$	2,052 16 90 $\frac{5}{8}$	2,304 4 63	1,814 27 68 $\frac{3}{8}$	4,118 31 35 $\frac{3}{8}$	6,171 8 30

1 poud = 36 pounds avoirdupois.

IV. *Account of a Torrent of Mud in the Plain of the LAGUNILLA,*
NEW GRANADA.

THE following account of a remarkable torrent of mud is extracted from a newspaper lately received from Colombia. The facts are attested officially by the local authorities. The first extract is a simple translation of an account dated "Tasajeras, Friday, February 21. 1845," and signed "R. J. Treffery."

"On Wednesday, the 19th instant, a little before seven, a. m., there was heard a great noise in the plain of the River Lagunilla *, and at the same time an earthquake took place. Immediately there appeared in the strait or ravine in the mountains from which the River Lagunilla arises, an immense flood of liquid clay, which pursued its course with the greatest rapidity through the whole plain on both sides of the river, carrying away woods of tall trees like straw, rolling them away, and covering them in such a manner as to leave no sign of there having been a wood at all. The same happened with regard to the houses and cottages which it met with in its course, overwhelming them with their inhabitants, and carrying away and burying those unhappy persons who were fleeing from death, so that nearly all the population of the higher part of the valley has been destroyed, and many who had escaped from the torrent and gained some high or enclosed place have found themselves insulated, and have perished by famine. It was quite impossible to succour them, for the whole plain was covered with a layer of mud and sand, so deep that no one could pass without being swallowed up. Some few persons, however, found an asylum by being near the edge of the torrent, and saved themselves by roads formed of the branches of trees.

"It is impossible to calculate with accuracy the number of persons who have perished ; but considering how few have escaped, it is probable that a thousand or more have been thus buried alive.

"In the plain, the torrent divided itself into two currents, the one following the course of the old river, or the ancient channel of the River Lagunilla, as far as the Magdalena. So great was the elevation of the flood at its first leaving the ravine, that a great torrent separated itself from the principal mass at a right angle, and followed its destructive course towards the north through the valley of Saint Domingo, choking up the woods and carrying them away like the principal torrent as far as the river Sabandiga, and here the trees and the mud formed a kind of dam, and held back the waters of the river so far as to threaten an inundation of all the low grounds by the shore, about the village of Guayabal. Providentially, a strong rain on Friday night increased the

* The Lagunilla is a small stream emptying itself into the river Magdalena, and situated in the north-western extremity of South America, in New Granada. Ibaguë, the town alluded to in the subsequent document, is some distance to the west of Santa Fé de Bogotá.

tributary streams of the Sabandiga, and the force of the water overcame the dam, and gave liberty to the imprisoned streams.

"This great torrent did not consist solely of mud, but was a mixture of stones, gravel, sand, and clay, joined with great masses of snow, which fell in such a quantity, that even in three days it had not entirely melted, for the mantle of mud which covered it so protected it from the heat, that many have probably perished, having lost their strength by the cold, who might otherwise have extricated themselves from the mass. This terrific inundation has been produced by the precipitating down of a piece of rock from the frozen desert of Ruiz, in which the River Lagunilla takes its source. The present aspect of the plain of Lagunilla is that of a desert of sand or sea shingle, with some islets of wood and a few great trees left standing by themselves, and the space of land covered may be calculated, at least, at four square leagues, or, perhaps, six leagues would not be an excessive calculation. The thickness of the layer of mud varies, being greater towards the higher part of the valley where the torrent was the deepest, so that there it reached to the branches of the highest trees. In whatever part it has been sounded, it gives a depth about the height of a man; but supposing that the medium depth be not more than a yard, and the superficial extent four square leagues, the quantity of matter poured down amounts to more than two hundred and fifty millions of tons."

With this account there is published a letter from Senhor J. Uldarico Leira to the Secretary of State for the Home Department, giving an account of the efforts made to assist the unhappy sufferers, and also an acknowledgment on the part of government of the services of the philanthropic citizens who thus assisted. We append some extracts from the former of these two documents.

"LAGUNILLA.

"Republic of New Granada. Government of the Province of Mariquita. Ibaguë, March 5. 1845.

"On the 23d of the last month, I announced to your Excellency the misfortune occasioned by the overflowing of the Lagunilla, and on the same day I set out with Senhor Andres Caicedo and my secretary, arriving at Los Peladeros on the 24th. There I dictated all the orders necessary to liberate those who remained insulated and exposed to certain death. In the midst of a melancholy scene, which at each step offered me some new picture of suffering, I had the consolation of saving more than eighty persons, who were in the midst of impracticable sloughs, full of wounds and bruises, and sinking through hunger and thirst. Assisted by Senhor Caicedo and the public authorities of the canton of Mariquita, I was enabled to provide subsistence for more than four hundred persons, whom I employed in assisting the sufferers, who thus received the little aid that I was enabled to give them.

“The wounded who had friends were conveyed to them, and those who had none were committed to the care of any person willing to receive them, and whose trouble I compensated. According to the data which I could collect while at Peladeros, there must have perished more than a thousand persons, in the six square leagues which I calculate to have been inundated, and the capital destroyed could not amount to less than half a million of dollars.

“The phenomenon which has occasioned these misfortunes was, in my opinion, produced by the falling down of a part of the frozen peak of Ruiz, carrying with it all the snow that covered it: the thawing did the rest, because it brought down all the immense mass of decomposed granite which covered the sources of the Lagunilla. Not content with these observations and the reflections which arose from them, I sent commissioners, who recognised in the same desert the occasion of such a disaster. I do not, however, know as yet all the results of their observations, as I returned to this place on the 1st inst.

“I visited the place from whence the River Lagunilla pours its streams from the mountain into the plain, and I there saw that the deluge had come from a height of 200 yards above the level of the river, spreading itself so as to take in the plain. From this point everything was converted into a sandy waste, and, with the exception of a few birds of prey, which were cruising about in all directions, scarcely a single living creature was to be observed in the whole extent. On a few insulated spots the inhabitants were to be seen, but reduced to the last extremities of hunger, thirst, and fatigue.

“The tobacco is generally destroyed, partly by the inundation, and partly by the terror, which prevented any effectual means being taken to preserve it: thus I fear the revenue will suffer considerably.”

THE
QUARTERLY JOURNAL
OF
THE GEOLOGICAL SOCIETY OF LONDON.

I. PROCEEDINGS
OF
THE GEOLOGICAL SOCIETY.

February 26. 1845.

JOHN FOWLER, Esq. C. E., of Stockton-on-Tees, was elected a Fellow of this Society.

The following communications were read: —

1. *On the Miocene Tertiary Strata of MARYLAND, VIRGINIA, and of NORTH and SOUTH CAROLINA.* By CHARLES LYELL, Esq., M.A., F.R.S., &c.

BETWEEN the hilly country of the United States and the Atlantic there intervenes a low and nearly level region, occupied principally by beds of marl, clay, and sand of the cretaceous and tertiary formations. Maclure, in 1817, in his "Geology of the United States," laid down, with no small approach to accuracy, on a coloured map, the general limits of this great plain, and of the granitic district lying immediately to the westward. He also pointed out, that at the junction of these great geological regions almost all the great

rivers descend suddenly by falls or rapids of moderate height, as the Delaware at Trenton, the Schuylkill near Philadelphia, the Potomac near Washington, the James River at Richmond, Virginia, the Savannah at Augusta in Georgia, and many others. At these points, therefore, the navigation is stopped, and a great many large cities have sprung up; so that the line which marks the western boundary of the tertiary, and the eastern of the granitic region, is at the same time one of peculiar geological, geographical, and political interest.

The general elevation of the great plain does not exceed a hundred feet, although it is sometimes considerably higher. Its width in the middle and southern States is very commonly from 100 to 150 miles. The tide, except in the more southern States, flows entirely across it, and the rivers intersecting it form large estuaries, which may have been due to the facility with which the incoherent materials of the cliffs were undermined and swept away, a process of waste still going on.

Throughout the greater part of the Atlantic plain, the cretaceous rocks, if present, are concealed by the overlying tertiary deposits, which consist chiefly of Miocene strata, extending from Delaware Bay to the Cape Fear River, and occupying portions of Delaware, Maryland, Virginia, and N. Carolina, an area about 400 miles long from north to south, and varying in breadth from 10 to 70 miles. There are, besides, some patches of the miocene formation in South Carolina and Georgia, where the Eocene, or older tertiary deposits, predominate almost exclusively, and where the limits of the miocene deposits have not yet been well ascertained.

I have endeavoured to show, in a former paper, read to the Society in February, 1843 *, that the fossils of Martha's Vineyard, an island off the coast of Massachusetts, especially the teeth of sharks, point to a near chronological connexion between the strata of that island and the miocene strata of Europe; but the evidence is far more complete and satisfactory in favour of a similarity of age between the deposits about to be described, which occur 350 miles to the south, or in Maryland and Virginia. In the last-mentioned States these formations extend over a wide area, and have been well described by Mr. Conrad, who identified them in age with the English crag, and called them "medial pliocene," and by Professors W. B. and H. D. Rogers, in their article in the *Philos. Trans. of Philadelphia* for 1836. These authors considered them entitled to the appellation of Miocene, as containing a proportion of recent shells corresponding to that known to characterise the miocene deposits of Europe.

The principal grounds which induce me to agree in this opinion, and to regard the beds of sand, clay, and marl now under consideration as corresponding in geological age with the crag of Suffolk, the faluns of the Loire, and other contemporaneous formations in Europe, are the following:—

First. On the banks of the James River and elsewhere I saw

* *Proceed. of Geol. Soc.*, vol. iv. p. 31.

them resting on eocene deposits, or on sand and clay containing an assemblage of shells resembling those of the London and Paris basins.

2dly. The genera of shells, and the amount of species by which they are represented, agree for the most part with those which characterise the European miocene beds. Many of the most abundant species are allied, and some few are identical.

3dly. The proportion of fossil shells identified with recent species amounts to about 17 per cent, or about one-sixth of the whole, in 147 species collected by me, the recent species agreeing almost entirely with those now living in the neighbouring parts of the Atlantic.

4thly. There is the same mixture of shells of northern and southern forms as in the French faluns.

5thly. Of ten species of corals, all but one agree generically with those of the miocene beds of Europe, and two at least specifically. One of these is a *Lunulite*, the same as a fossil from the Suffolk crag and also from the faluns of Touraine; a second, *Anthophyllum lineatum*, is also common in the French faluns.

6thly. Among the remains of fish are several of the shark family, agreeing with species from the miocene beds of Europe, the faluns of Touraine, the molasse of Switzerland, and the tertiary formation of Malta, among which I may mention *Carcharias megalodon*, *C. productus*, *Lamna xiphodon*, *L. hastalis*, *L. cuspidata*. The ossicles also of the ears of fishes closely resemble those occurring in the Suffolk crag.

7thly. The absence of reptiles is another point of analogy, as also the presence of huge cetaceous remains.

The miocene deposits of the United States consist chiefly of incoherent sand and clay, and in this respect bear a strong resemblance to those of the same age in Europe. The associated siliceous sand imparts a sterile character to the space they occupy, but the soil has often been fertilised by the use of shell marl, derived by the agriculturist from parts of the same formation, a practice which Mr. Ruffin, of Petersburg, Virginia, editor of the *Farmer's Register*, has done much to promote. This use of the miocene marl and fossil shells affords another singular point of coincidence between the American strata, the English crag, and the faluns of the Loire, all of which furnish the same fertilising calcareous materials for improving light soils.

I began my examination of these middle tertiary deposits in the suburbs of Richmond, Virginia, where I saw in Shockoe Creek red clay and sand, from which I obtained *Artemis acetabulum*, and casts of miocene species of *Astarte* and *Mactra*, reposing on eocene marls with characteristic shells. Between the two formations, a remarkable bed of whitish and yellowish siliceous clay intervenes, from twelve to twenty-five feet thick, of an extremely fine texture. It affords a very sterile soil, and its course through the country is marked on the surface by a band of meagre vegetation, without trees or shrubs. It has been described by Professor

Wm. Rogers, in his State Report on the Geology of Virginia for 1840. When examined under the microscope, it is found to consist of an impalpable siliceous powder, derived from the cases of minute animalcules. Dr. Bailey has shown that the siliceous skeletons belong to several species of *Navicula*, *Gaillonella*, *Actinocyclus*, and other genera. The position of the infusorial earth, the bed being perfectly conformable to the miocene strata above, and the eocene below, is not decisive of its age; but I understand that the species are considered by Messrs. Tuomey, W. B. Rogers, and Bailey, as implying that it belongs to the miocene formation; and Dr. Mantell, who has examined them, informs me that many of them belong to living species.

On the right bank of the James River, at City Point, Virginia, about twenty miles below Richmond, in a cliff about thirty feet high, I observed the yellow and white miocene sands resting on dark green earth and marl of the eocene formation, just as the yellow sands of the crag rest on the blue London clay in some parts of the coast of Suffolk and Essex. Several miles below City Point, the overlying sandy deposit contains a bed of shelly marl, sometimes fifteen feet thick, as at Evergreen. Here I was much struck with the profusion of an *Astarte* (*A. undulata* Conrad), which resembles very closely, and may possibly be merely a variety of, one of the commonest and most characteristic fossils of the Suffolk crag, *A. bipartita*. The other shells also, of the genera *Natica*, *Fissurella*, *Artemis*, *Lucina*, *Chama*, *Pectunculus*, and *Pecten*, reminded me of shells of our crag and the French faluns, although the species are almost all distinct. The large *Venus tridacnoides*, however, is very peculiar, and the *Perna maxillata* is unlike any Suffolk or Touraine fossil, though closely allied to a miocene shell of the Mayence basin on the Rhine. A single coral is found plentifully at Evergreen, resembling an *Astrea*, and called by Mr. Lonsdale *Columnaria* (?) *sex-radiata*. It differs from the genus *Astrea*, as defined by Ehrenberg, in the stars not being subdivided. Large flattened masses of this coral, upwards of two feet wide, were lying on the beach, washed out of the marl. The teeth of sharks in the banks of the James River agree, some of them specifically, with those of the European miocene beds, and several cetaceous bones, analogous to fossils of the Suffolk crag and Touraine faluns, are frequently met with.

On the right bank or southern coast of the river, about a mile and a half south-west of Coggin's Point, a bluish green marl occurs, about sixteen feet thick and not stratified, in which, assisted by Mr. Ruffin, jun., I gathered in a short time more than thirty species of shells, beautifully preserved, of the genera before mentioned, as also *Oliva*, *Turritella*, *Teredo*, *Dentalium*, *Crassatella*, *Corbula*, *Panopæa*, *Cyprina*, *Tellina*, *Cardita*, *Ostrea*, and *Balanus*. The *Lucina divaricata*, precisely like that of Touraine, or the living West Indian variety, was not rare. This deposit was covered by a bed of reddish clay about six feet thick, without fossils. In many places a remarkable variety of bright green

marl, somewhat of the colour of chlorite, alternates in this region with the yellow sand and white shelly marls, which more commonly characterise the miocene deposit.

Passing to the other side, or northern shore, of the estuary of the James River, I observed at the Grove Landing, near the old deserted village of Jamestown, and seven miles south of Williamsburg, Virginia, a range of cliff about forty feet high, in which greenish and yellowish sandy marls of the miocene formation are well exposed. At the top of the cliff is a bed of red earth, without fossils, about ten feet thick. Below this is a layer of shells almost entirely composed of *Chama congregata*, both valves in each individual being usually found united. Below is a mass of shells about twelve feet thick, consisting almost entirely of the genus *Pecten*, but associated with others, of which the *Astarte undulata* before mentioned is the most abundant. The *Pecten*s are closely packed together, with only a slight quantity of accompanying earth. A geologist who should merely collect the shells which have fallen in great numbers on the beach would imagine that bivalves preponderate, to the exclusion of univalves, which, however, is not the case. The univalves are more readily destroyed by frost, rain, and the sun, and have therefore disappeared after exposure, but on digging into a fresh stratum, I met with shells of the genera *Conus*, *Oliva*, *Marginella*, *Fusus*, *Pyrula*, *Murex*, *Natica*, and others. I found no admixture of freshwater or land shells here or in any other locality.

At Burwell's Mill, near Williamsburg, I found a bed of marl about twelve feet thick, very rich in shells, so that I collected there more than seventy species, besides seven species of corals, mingled confusedly with the shells, in which last there appeared to be no order of arrangement, except that in one part, near the top, the *Chama congregata*, accompanied with a *Fissurella*, and a few others, predominated greatly. Among other signs of the slow accumulation of this mass of sandy marl and shells, I may mention that full-grown barnacles and corals are attached to several of the *Pecten*s and other large shells. About one in five of the species of mollusca procured from this marl pit are not distinguishable from those now living in the neighbouring sea.

That remarkable variety of miocene marl which is of a bluish green colour, and which I have mentioned as occurring near Coggin's Point, is well exhibited in a valley near the town of Petersburg, Virginia, where it is used for fertilising the land. It rests on eocene strata, also containing green earth, but of a darker colour. The blue miocene marl is about sixteen feet thick, rich in shells, and is covered by yellow sand, and mottled red and grey clay, about fifty feet thick, with many other sandy strata still higher in the series, which may be observed near the summits of the hills bordering the valley.

All the miocene strata of the James River are horizontal, but the upper surface has been denuded very unevenly, and often with a deeply indented outline, after which the whole country has been

reduced to one level by the deposition of an incumbent mass, consisting chiefly of red clay. The great width of estuaries such as that of the James and other rivers which have narrow channels in the higher and mountainous region, may probably be attributed to the facility with which, on the eastern coast of America, the action of the tides has removed the soft and incoherent tertiary deposit, when the land was gradually emerging from the sea. There is reason to believe, from what we know of the coast of S. Carolina and Georgia, that this emergence was accompanied by oscillations of level, which would greatly facilitate and prolong the period of the denuding operations.

NORTH CAROLINA.

In the cliffs at Wilmington, North Carolina, resting on a calcareous eocene rock, are seen miocene shelly strata of the ordinary character, in which I collected about thirty species of shells. The recent species bore a larger proportion than usual to the extinct; but this may be owing to the circumstance that two-thirds of the whole consisted of marine bivalves, which is rather a larger proportion than that observed in the fossil miocene fauna, amounting to about 150 species, which I collected in Virginia. I have invariably found that the proportion of marine bivalves identical with the recent, whether in the English crag, the faluns of Touraine, or other tertiary formations, is greater than that of the marine univalves, a result in perfect harmony with the law of geographical distribution of living mollusca pointed out by M. Philippi, who has shown that the range of species in the marine bivalves is far more extensive than in the univalves. In Touraine I found the per-centage of recent species vary in the faluns as much as 10 per cent., and even more, in different places not very remote from each other; but when the number in each locality was considerable (150 species for example), this variation diminished. As, however, it would be very rash to assume that all the miocene deposits of the United States, especially in countries as far apart as Maryland and South Carolina, were of strictly contemporaneous origin, the fossil faunas of each region should be carefully distinguished, and considered separately.

FOSSILS OF THE MIOCENE STRATA.

Mollusca.—Mr. Conrad, in his work on the fossils of the tertiary formations of the United States, Philadelphia, 1838, has described and figured many of the miocene shells, but unfortunately his work has never been completed. The same author has given a catalogue of 187 shells of the middle tertiary, or miocene formation, in the Appendix to Dr. Morton's "Organic Remains" of the Cretaceous Group. He has also described and figured some species in Silliman's Journal, vol. xli. p. 344. In his own cabinet, he has shown me more than 200 species of shells belonging to this formation, of which he considered about a sixth part to agree with

species now living, and he supposed that a somewhat larger proportion would be identified, were our knowledge of the living mollusca more perfect.

I shall confine myself to remarks on those shells, amounting to 147 species exclusive of Balani, which I collected myself, and which I have carefully compared, with the assistance of Mr. G. B. Sowerby, with the tertiary shells of Europe, and with recent species.

The following table will show the miocene genera above alluded to, and the number of species in each:—

Miocene Mollusca of Virginia and South Carolina.

Marine Univalves (63 species).

Marginella	- 3.	Fulgur (Fusus)	- 3.	Turritella	- 5.
Voluta	- 2.	Cerithium	- 1.	Trochus	- 2.
Oliva	- 3.	Pleurotoma	- 6.	Margarita	- 1.
Conus	- 2.	Cancellaria	- 3.	Solarium	- 1.
Terebra	- 1.	Natica	- 2.	Calyptrea	- 2.
Buccinum	- 7.	Sigaretus	- 1.	Crepidula	- 2.
Purpura	- 1.	Bulla	- 2.	Fissurella	- 1.
Typhis	- 1.	Scalaria	- 1.	Dentalium	- 1.
Fusus	- 7.	Eulima	- 1.	Ditrupea	- 1.

Marine Bivalves (84 species).

Solen	- 1.	Mysia	- 1.	Pectunculus	- 1.
Panopæa	- 2.	Lucina	- 10.	Nucula	- 2.
Myodora	- 1.	Sphærella	- 1.	Crenella	- 1.
Mactra	- 7.	Astarte	- 10.	Perna	- 1.
Gnathodon	- 1.	Cytherea	- 1.	Lima	- 1.
Crassatella	- 2.	Venus	- 5.	Modiola	- 1.
Amphidesma	- 5.	Artemis	- 1.	Pecten	- 5.
Sphæria	- 1.	Isocardia	- 1.	Plicatula	- 1.
Corbula	- 3.	Cardium	- 1.	Ostrea	- 3.
Saxicava	- 2.	Chama	- 1.	Anomia	- 1.
Petricola	- 1.	Cardita	- 2.	Orbicula	- 1.
Tellina	- 2.	Arca	- 4.		

Of the 147 species above enumerated, I have been able to identify the following 23 with recent species:—

American Miocene Shells identified with Recent Species.

Purpura lapillus Lin. Petersburg, Virginia.

Fusus cinereus Lin. Petersburg, Virginia.

Pyrula (Fulgur) carica Say. Petersburg, Williamsburg, &c.

P. canaliculata Say. Maryland.

Natica duplicata Say. Petersburg, &c.

N. heros Say. Maryland.

Calyptrea costata. Wilmington, North Carolina. (Syn. *Dispotæa ramosa* Conrad.)

Identical with a recent species which I have from Valparaiso.

Crepidula fornicata Lam. Williamsburg.

Dentalium dentalis. Wilmington.

Ditrupea gadus. Williamsburg, Maryland; and Petersburg, Virginia.

Solen ensis Lin. Williamsburg and Wilmington.

Panopæa Americana. Maryland and Petersburg.

Same as *P. Aldrovandi*.

Macra lateralis Say. Petersburg.

Same as *M. similis*.

Lucina divaricata Lam. Williamsburg, Maryland; and Petersburg.

Identical with a West Indian variety.

L. anodonta Say. Evergreen, Virginia; and Wilmington, North Carolina.

L. squamosa. Petersburg.

L. contracta Say. Wilmington, North Carolina; and Williamsburg, Maryland.

It appears to be the same as *L. radula*.

Astarte lunulata Con. Williamsburg.

Identical with a recent shell from South Carolina.

Venus mercenaria Lam. Wilmington, North Carolina.

Nucula limatula Say. Petersburg.

N. proxima Say. Williamsburg.

Identical with recent specimens on the coast of Massachusetts.

Modiola glandula Totten. Petersburg.

Identical with a recent specimen from Massachusetts.

Pecten magellanicus Lam. Petersburg.

The above list would give a proportion of about 17 per cent. of recent species, or about one-sixth; but I have no doubt that if we possessed in London larger collections of the shells now inhabiting the American seas, I should be able to prove that a greater number of them agreed with fossils of the miocene strata in the United States. Thus I have not included *Anomia ephippium*, because the specific characters in this genus are so unsatisfactory; and I have not seen the recent shell which Mr. Conrad identifies with *Lucina crenulata*; nor have I been able to identify *Artemis acetabulum*, given as a recent species by Mr. Conrad, which does not agree with *A. concentrica* Lam., nor with the species which inhabits the Pacific coast of South America.

The general resemblance of the American fossils of this era with those of the Suffolk crag and faluns of the Loire was so great, that I was surprised, on a closer comparison, to find that I could only identify 9 species as common to both sides of the Atlantic, and that out of 147 American fossils, I could only find 13 species in the European miocene, which were so closely allied as to be entitled to be regarded as geographical representatives. A great part, therefore, of the analogy consists in the similarity of the genera.

List of Species common to the American and European Miocene Strata.

1. *Fusus rostratus* Dujardin.

Found by me at Burwell's Mill, Williamsburg, Maryland; and agreeing with a common fossil of the faluns of Touraine.

2. *Purpura lapillus* Lin. Petersburg, Virginia.

American variety: probably the same species as *P. crispata* of the red crag, Suffolk, some varieties of which agree with the European *P. lapillus*.

3. *Turritella plebeia* Say. Maryland.

This agrees perfectly with an abundant fossil of the Touraine faluns, to which Dujardin has given the name, incorrectly perhaps, of *T. Linnæa*.

4. *Dentalium costatum*. Min. Con., Williamsburg.
This species agrees most perfectly with that of the Suffolk red and coralline crag. It is called *D. dentalis* by Conrad.
5. *Ditrupa gadus*.
I cannot distinguish this from a shell of the English crag.
6. *Lucina divaricata*. Petersburg, Va.
Identical with the Touraine variety.
7. *Lucina contracta* Say.
Seems undistinguishable from the recent *L. radula*, which is also found in the Suffolk crag.
8. *Perna maxillata* Lam.
Mr. Conrad has considered this the same as the fossil which occurs in the Mayence basin, which seems to agree well, though I have not perfect specimens to compare.
9. *Astarte undulata* Say.
I have some specimens of *A. bipartita* from the Suffolk crag, which agree perfectly with the American fossil, except that in the latter the sides of the hinge teeth are much more distinctly grooved. A few only of the English specimens exhibit a faint trace of this grooving. The species named by the Americans *A. vicina*, *A. arata*, *A. cuneiformis*, *A. obruta*, *A. perplana*, appear all to be varieties of the above species.

*Geographical Representatives ; or, American Miocene Species
closely allied to European Miocene Fossils.*

1. *Oliva*, n. sp. Wilmington.
Resembles *O. hispidula*, and may be considered as representing *O. Dufrenoyi* Bast., of the Touraine faluns.
2. *Voluta mutabilis*. Maryland and Petersburg, Va.
Decidedly represents *V. Lamberti* of the English crag and French faluns.
3. *Buccinum trivittatum* Say. Maryland and N. Carolina.
Closely resembles a common Touraine species, which Dujardin has called *B. elegans*, a name which cannot be retained. In the American fossil the outer lip is not thickened, as in that from Touraine.
4. *Cancellaria lunata*. Maryland.
It comes very near to a crag species in Mr. Wood's collection, and is allied to a Bordeaux species given me by M. Deshayes under the name of *C. contorta*.
5. *Trochus Audibarti* Bast. Williamsburg, Maryland.
The American shell is rather more acuminate than that of Bordeaux, but is so near that some may consider it a variety.
6. *Solarium*, new species. Williamsburg.
Nearly allied to *Solariella maculata*, Searles Wood, An. Nat. Hist. 9. t. 5. f. 7. from the coralline crag, Suffolk.
7. *Calyptrea sinensis*? Petersburg, Va.
This fossil nearly resembles, if it be not the same as, *C. sinensis*, found in the Suffolk crag.
8. *Panopæa reflexa* Say. Petersburg.
Nearly allied to *P. Faujasii*, crag, Suffolk.
9. *Corbula elevata* Con. Maryland.
Approaches near to the recent *C. nucleus*, a Suffolk crag species.
10. *Tellina lusoria*. Williamsburg.
Nearly allied to *T. donacina*, Suffolk crag.
11. *Astarte lirata* Conrad.
Nearly allied to *A. gracilis*, Coralline crag, Suffolk.
12. *Isocardia rustica*. Maryland.
Allied to *Isocardia cor*, Suffolk crag.
13. *Pecten Jeffersonius*. Petersburg.
Allied to *P. solarium* of the faluns of Touraine.

Miocene Species of Forms peculiar to America.

While the analogy of the American and European miocene shells is so striking, there are also some species of forms quite peculiar to America; *e. g.* :—

- | | |
|--|---|
| 1. <i>Oliva idonea</i> . | 7. <i>Calyptraea costata</i> (C. <i>ramosa</i> Conrad). |
| 2. <i>Fusus quadricostatus</i> Say. | 8. <i>Gnathodon</i> Grayi. |
| 3. <i>F. sulcatus</i> . | 9. <i>Venus Tridacnoides</i> . |
| 4. <i>F. parilis</i> Con. | 10. <i>V. mercenaria</i> Lam. |
| 5. <i>Pyrula</i> (Fulgur) <i>carica</i> Say. | 11. <i>Modiola glandula</i> Totten. |
| 6. <i>P. canaliculata</i> Say. | 12. <i>Pecten magellanicus</i> Lam. |

The six species in italics in the above list are recent, and are confined to the western side of the Atlantic, and these characteristic forms imply that the beginning of the present geographical distribution of mollusca dates back to a period as remote as that of the miocene strata. It will be also seen that several of the 23 miocene shells identified with recent species in the list p. 419-20. are now inhabitants of the American side of the Atlantic.

On the other hand, when we examine the fossil shells of the European miocene strata, we find most of those which are identifiable with living species to belong to the British seas, to the Mediterranean, or to the coast of North Africa, and not to extend to the American side of the Atlantic, a fact which may be illustrated by the following list of species.

European Miocene Shells found living on the Eastern, and not inhabiting the Western, Side of the Atlantic.

	TOURAINÉ.	CRAIG.	LIVING.
1. <i>Cypræa coccinella</i> - -	+	+	British and Medit.
2. <i>Erato cypreola</i> - - -	+	+	British.
3. <i>Terebra plicaria</i> - - -	+		North Africa.
4. <i>Buccinum mutabile</i> - -	+		Mediterranean.
5. <i>Columbella</i> (Bucc.) Linnei	+		Mediterranean.
6. <i>Cerithium lima</i> - - -	+		Brit. and Mediterranean.
7. <i>Eulima Cambessedesii</i> -	+		Brit. and Mediterranean.
8. <i>Trochus fanulum</i> - -	+		Mediterranean.
9. <i>Trochus striatus</i> - -	+	+	Mediterranean.
10. <i>Siliquaria anguina</i> - -	+		Medit. and Atlantic.
11. <i>Fissurella neglecta</i> - -	+	+	Mediterranean.
12. <i>Petricola ochroleuca</i> -	+		Medit. and Ireland.
13. <i>Tellina crassa</i> - - -	+	+	British.
14. <i>Lucina columbella</i> - -	+		North Africa.
15. <i>Arca lactea</i> - - - -	+	+	British.

No one of the above shells is found fossil in the American miocene strata, and this fact strongly confirms the opinion before stated respecting the high antiquity of the separation of the existing molluscan faunæ, which we see may be traced back to a period when about four fifths of the species differed from those

now living on the globe. The large *Pyrulæ* of the sub-genus *Fulgur*, and several other forms above enumerated, list, p. 419-20., would enable a conchologist, only acquainted with recent shells, to distinguish a set of American from a set of European miocene fossils. The genera *Pholadomya* and *Gnathodon*, and several others found in the miocene beds of the United States, would also enable the conchologist to recognise the American type.

It is worthy of remark, that the recent shells found in the American miocene beds are not only in about the same proportion to the extinct as is observed in the Suffolk crag or in the faluns of Touraine, but they also agree specifically in most cases with mollusca now inhabiting the neighbouring Atlantic. Now most of the recent miocene species of Touraine agree with species now living on the western coast of France or in the Mediterranean, and those of our crag are identifiable with species living in the British seas. This result appears to me to confirm the accuracy of the conchological determinations, for if any one of those palæontologists who are unwilling to believe that species pass from one geological period to another, should maintain that the living species are so numerous, and often resemble each other so closely, that false identifications may easily have arisen, I reply, that in that case, according to a fair calculation of chances, nine-tenths of the American miocene species said to be *recent* ought to have been identified with exotic species, instead of being found to agree with members of that very limited fauna at present known on the American shores. The same argument is clearly applicable to the identifications which have been made of fossil and recent shells in the European miocene formations. With the exception of one *Calyptræa*, I find no one of the miocene shells which I have identified with recent species to be identical with shells of the Pacific. The analogy is to an Atlantic, not a Pacific fauna.

Among other points of analogy between the miocene fossils on the banks of the James River and those of Touraine, I ought not to omit mentioning the multitude of large shells of the genus *Pecten*, as *P. Jeffersonius* and others, occurring near Williamsburg, (Maryland,) just as the large *Pecten Solarium* occurs in the faluns of the Loire near Doué. Nothing similar is observed in the eocene fossils, whether European or American. The same may be said of the large and conspicuous shells of the genus *Panopæa*, found in our Suffolk crag, and in the American miocene beds, but not in the older tertiary strata.

As it is very rare to meet with any land or freshwater shells in the red and coralline crag of Suffolk, so are they almost unknown as yet in the American strata of the same age. The *Gnathodon*, an estuary shell, has been found in several places, and I met with two odd valves of a *Cyrena*, well preserved in the miocene strata of Petersburg, Va. The species is rather larger than *C. consobrina* from the Nile. The *Buccinum quadratum* of Conrad, doubtless a marine shell, might easily be mistaken for a *Melanopsis*.

Even in Touraine, where the bones of mammalia are not un-

common in the marine beds, extremely few land and freshwater shells are met with.

Climate of the Miocene Shells. — Upon the whole, the shells of this formation in Virginia and Maryland resemble those of Touraine and Bordeaux more than the fossils of the Suffolk crag, as we might have expected from their nearer correspondence in latitude. Thus, for example, the genera *Conus*, *Oliva*, *Marginella*, and *Crassatella* (represented by large species), with other forms of warmer seas, which are wanting in our crag, are common to the miocene beds of Virginia, Maryland, Touraine, and Bordeaux. Yet when we consider that the shelly deposits on the James River, in the United States, are in the 37th degree of north latitude, while the French faluns are in the 47th, we are surprised to see so great an analogy in those characters by which the climate of a conchological fauna may be inferred. The American shells do not seem to indicate a more southern latitude by 10°, and the same remark applies equally when we compare the most southern beds of North Carolina with those of Bordeaux. We find in all these localities a great admixture of northern forms, as if the isothermal lines in the climate of the miocene period took a curve to the south when drawn from Europe to America, as they do now.

Polyparia. — The fossil corals which I observed in different miocene localities were usually few in number, both in species and individuals, with the exception of the *Columnaria* (?) *sex-radiata*, which resembles an *Astrea*, and is very conspicuous, from its size, in the shelly marls near the banks of the James River. The scarcity of these zoophytes may be a local accident, depending on the general rarity of calcareous deposits of this age in the United States. The following is a list of ten species collected by me, and of which a description will be communicated by Mr. Lonsdale in a subsequent report.*

MIocene SPECIES.	LOCALITIES.
1. <i>Columnaria</i> ? <i>sex-radiata</i> Lonsdale	{ Evergreen, on James River, Virginia ; Petersburg, Virginia.
2. <i>Anthophyllum lineatum</i> Lonsdale (<i>Caryophyllia lineata</i> Conrad)	
3. <i>Astrea hirtolamellata</i> ? Michelin	Williamsburg.
4. <i>Heteropora</i> ? <i>tortilis</i> Lonsdale	Petersburg and Williamsburg, Virginia.
5. <i>Cellepora informata</i> Lonsdale	Petersburg, Virginia.
6. <i>C. quadrangularis</i> Lonsdale	Williamsburg, Evergreen, Virginia.
7. <i>C. similis</i> Lonsdale	Williamsburg, Virginia.
8. <i>C. umbilicata</i> Lonsdale	Williamsburg, Virginia.
9. <i>Escharina tumidula</i> Lonsdale	Petersburg, Virginia.
10. <i>Lunulites denticulata</i> Conrad	Williamsburg, Virginia.

Two species of the above list, namely *Anthophyllum lineatum*, identical with a Touraine species, and *Lunulites denticulata*, agreeing with one found in the Suffolk crag and faluns of Touraine, correspond with European fossils of the same age.

With respect to climate, Mr. Lonsdale regards this collection as indicating a temperature exceeding that of the Mediterranean,

* See this Report among the miscellaneous articles in the present Number of the Journal.

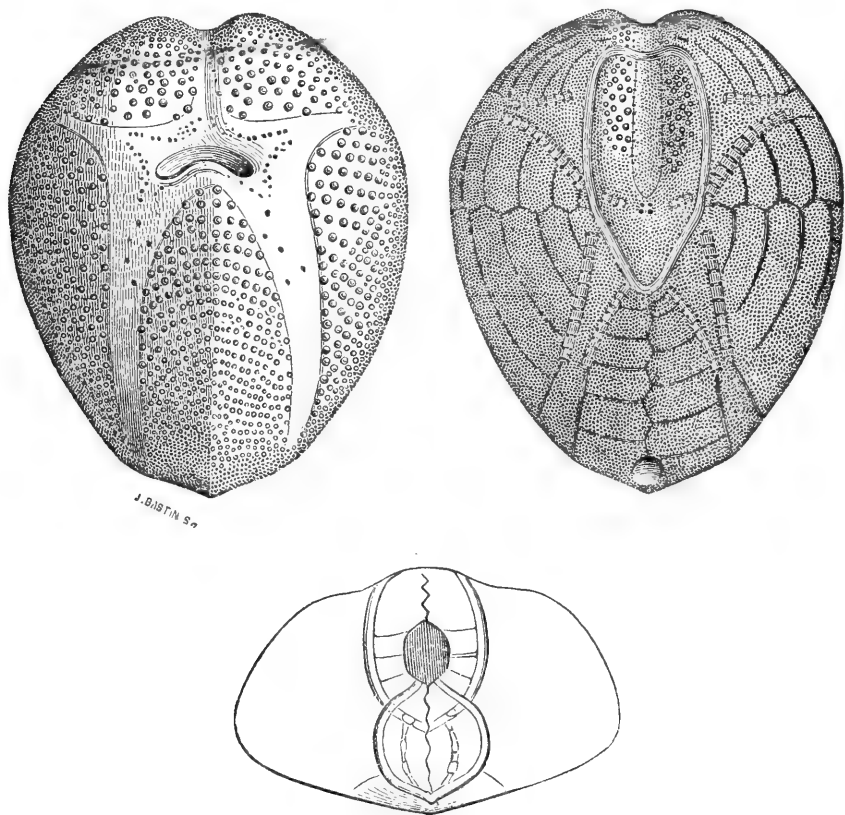
nearly corresponding with that of the faluns of Touraine, warmer than that implied by the polyparian fauna of the crag, and not so tropical as that of the Bordeaux tertiary beds.

Fossil Echinodermata.

In the shelly strata near Coggin's Point, on the James River, Virginia, I found a species of the *Spatangus* family, of the genus called by Agassiz *Amphidetus*, which also occurs in the English crag, and in the living fauna of Europe. I also found an *Echinus* at Williamsburg, and the spines of a second species. My friend, Professor E. Forbes, has favoured me with descriptions of these.

(*Family Spatangaceæ.*)

1. *Amphidetus Virginianus* Edw. Forbes.



Amphidetus Virginianus (natural size).

Body broadly ovate; elevated and truncate posteriorly. Back oblique; dorsal impression lanceolate-scutate, area very slightly excavated: ambulacral spaces broad, triangular, depressed; interambulacral spaces slightly convex. Anteal furrow broad, shallow; sides slightly gibbous; subanal impression broadly obcordate; post-oral spinous space broadly lanceolate.

Dimensions of the smaller but more perfect specimens.

Lon. unc. $1\frac{1}{12}$; Lat. $1\frac{8}{12}$; Alt. 1.

Number of pairs of ambulacral pores.*

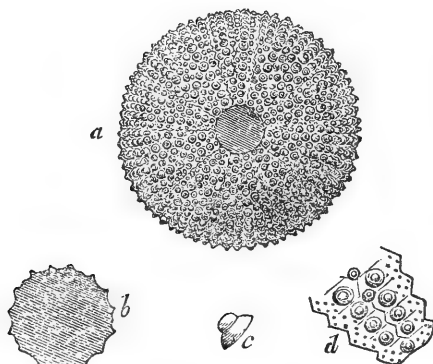
Ant. lat. dors. amb. 8 + 10.

Post. lat. dors. amb. 13 + 8.

Loc. Petersburg.

(Family *Cidarites*.)

2. *Echinus Ruffinii* Edw. Forbes.



a, *Echinus Ruffinii*, viewed from above.

b, Ditto, mouth.

c, Ditto, a spinigerous tubercle.

d, Ditto, ambulacral plates and arrangement of pores.

(*a*, *b*, natural size; *c*, *d*, enlarged.)

Body subdepressed; ambulacral and interambulacral plates with several primary tubercles on each, closely ranged, having circles of secondary tubercles surrounding their (broad) bases; rows of pores very oblique, three pair of pores in each row, the uppermost distant from the other two. Beneath concave, mouth broad, widely notched, opposite each avenue. Anus narrow.

Lat. 1 unc.; Alt. $\frac{9}{12}$; Lat. apert. $\frac{5}{12}$.

The primary tubercles, being very numerous and of almost equal size, give the testa a very granulated appearance.

Loc. Williamsburg, Virginia.

3. *Spines of an Echinus from James River*. Virginia.

Ridges fine, numerous; interstices apparently smooth, broader than the ridges.

Fish.

The remains of fish consist chiefly of teeth of the shark family, all belonging to existing genera.

1. *Carcharias megalodon*. Evergreen, James River.

2. *Lamna xiphodon*. Evergreen, precisely like specimens I have seen from Touraine.

3. *L. hastalis* (*Oxyrhina*). Evergreen, Virginia, like a specimen from Martha's Vineyard, and in the molasse of Switzerland.

4. *L. cuspidata*. James River, also common to the molasse.

5. *Carcharias productus*. Evergreen, also from the miocene of Malta.

Several other shark's teeth, and the ossicles of the ears of fishes, which I found in the miocene strata of Petersburg, Virginia, were very analogous to European miocene fossils.

* In another specimen the number was found to be —

Ant. lat. dors. amb. 8 + 13.

Post. lat. dors. amb. 11 + 11.

And four pair additional on each side of the ovarian holes.

Mammalia.

The vertebræ of whales, apparently similar to those before described as found in Martha's Vineyard, occur in the miocene beds of Petersburg and other places.

In the museum at Baltimore, the grinder of a Mastodon was shown me, evidently distinct from that of *M. giganteus*. It had been recognised by Mr. Charlesworth as the *M. longirostris* Kaup, and had been so ticketed by him. Professor Ducatel had the kindness to allow me to take the specimen to Philadelphia, where Dr. Harlan identified it with the *M. longirostris* by comparison with casts sent to him by Mr. Kaup. The tooth is narrower than in the common *Mastodon giganteus*, and the parallel rows of transverse mammillary processes, instead of being divided by distinct hollows, are connected together by projecting spurs.

I was informed that this tooth was found at the depth of 15 feet from the surface of a bed of marl, near Greensburgh, in Caroline County, Maryland. Though I have not visited the place, I have little doubt that this Mastodon was a miocene fossil, and it occurs in beds of the same age on the Rhine.

APPENDIX.—*Extract of a Letter from W. LONSDALE, Esq. F.G.S., to Mr. LYELL, on the Indications of Climate afforded by the Miocene Corals of Virginia.*

“July, 1845.

“From ten fossil species of Polyparia belonging to different families, it is difficult to form an opinion respecting the climate in which they were produced. Nevertheless, as recent lamelliferous corals are well known to be markedly distributed as respects climate, the following notice is submitted for consideration. The district in Virginia whence the miocene polyparia were procured being situated in about 37° of north latitude, is on the same parallel with the southern coast of the Mediterranean westward of Tunis, and the northern portion eastward of that point; and as very little appears to be known of the distribution of recent corals on the coasts of the United States, it is proposed to compare the nature of the fossil genera with that of those living in the Mediterranean; it is hoped that no great objection can be advanced against this comparison, or mode of inferring climate, as species are disregarded, and as the polyparia of the Bermudas and the West Indies agree generically with those of the Red Sea and Indian Ocean. The ten species belong to seven genera, *Columnaria* (?), *Astrea*, *Anthophyllum*, *Heteropora*, *Cellepora*, *Lepralia*, and *Lunulites*, the first three being lamelliferous Anthozoa; and though *Columnaria* is an extinct genus, yet it is believed that its requirements may be safely inferred to have been analogous to those of *Astrea*. *Heteropora* is also only found fossil; but being

considered to be a true *Tubuliporidae*, its habits may likewise be inferred: and the three last are well-known genera belonging to *Bryozoa*. The ascertained lamelliferous Anthozoa of the Mediterranean exhibit, when tabulated, a marked character, consisting almost wholly of simple or ramose groups, not numerous in genera or species, though abundant in specimens, and occasionally of ample growth, with very diminutive representatives either in number or size of the great *Meandrinae*, *Madrepore*, *Astrea*, *Porites*, and numerous allied genera which swarm in the Red Sea, the Bermudas, the West Indies, and the Pacific and Indian Oceans. A perfect distinction, as a whole, may therefore be stated to exist between the Polyparia of the Mediterranean and those of southern seas; while in more northern regions there are representatives, very limited as to species, of the simple and ramose polypidoms of the Mediterranean.

“On attempting to compare the miocene fossil *Anthozoa* of Virginia with those of the Mediterranean, it will be found that the *Anthophyllum* has no generic representative, all the existing species, as restricted by Ehrenberg, belonging to the Red Sea and Indian Ocean; and if the fossil specimens be regarded as young, their dimensions are not inferior to those of *A. musicale* in the same stage of developement — that the *Astrea* has an equivalent in the *Astrea mediterranea* of M. Risso, or in a *Porites* discovered by Prof. E. Forbes; but the *Columnaria*, an abundant coral, exhibits dimensions allied to those of analogous genera of warmer seas. Again, as respects the *Heteropora*, *Cellepora*, and *Escharina*, no satisfactory inference can be formed regarding climate, *Tubuliporidae* and similar *Celleporidae* being universally distributed; but *Lunulites* have been found only in the Mediterranean and more southern latitudes. The comparison, therefore, would lead to the inference, that a climate rather exceeding the one which prevails nearly throughout the Mediterranean existed in the region where these fossils lived; and it must be borne in mind, that, as in plants so in corals, size cannot be assumed as the sole indication of temperature, but the abundant developement of species of peculiar genera and families, whether the first be of large or small dimensions.

“It is desirable next to allude briefly to the relative geological position of the Virginia deposit as respects some European miocene accumulations, to the extent which each may appear to justify a comparison. The formations referred to are the crag of England, the faluns of Touraine, the deposits near Bordeaux and Dax; and the characters of the *Anthozoa* in each district will be again considered as the principal test of temperature. The crag, according to Mr. S. Wood’s extensive list*, contains only four species of lamelliferous Polyparia, with two *Lunulites* and one *Orbitulites*, the first including a *Fungia*, a *Turbinolia*, and two corals, believed to be allied to genera living in the Mediterranean: one of the

* Annals of Nat. Hist. January, 1844.

Lunulites is also considered to be identical with the species found in Virginia. The Polyparia of the crag exhibit, therefore, a marked absence of the genera characteristic of high temperatures. The Touraine miocene strata contain, according to the fine series collected by Mr. Lyell, about nine species of *Anthozoa* and three of *Lunulites*, the former including an *Anthophyllum*, believed to be the species found in Virginia, two *Turbinoliæ* and two *Astreæ*, the whole indicating a somewhat greater temperature than that of the crag. The Bordeaux and Dax deposits include, according to M. Michelin's work on the fossil corals of France, eleven lamelliferous *Anthozoa* and two *Lunulites*, the former comprising a *Dendrophyllia*, believed to be identical with a Touraine species; six *Astreæ*, one *Gemmipora*, one *Porites*, and two *Madreporæ*, or an aggregate representative of a Red Sea list of polyparia. Lastly, the Turin polypidoms, for a knowledge of which I am wholly indebted to M. Michelin's work, present no less than 73 species of lamelliferous *Anthozoa*, a tabulated list of which will bear a detailed comparison, as respects genera, with similar summaries of Red Sea, or tropical polypidoms. From these data it may perhaps be inferred, that the American deposit was accumulated in a climate superior to that of the crag, possibly equal to that of the faluns of Touraine, but inferior to that of Bordeaux."

2. *Observations on the WHITE LIMESTONE and other EOCENE or Older Tertiary Formations of VIRGINIA, SOUTH CAROLINA, and GEORGIA.* By CHARLES LYELL, Esq., M.A., F.R.S., &c.

THE tertiary deposits occupying a lower position than the Miocene strata described in the last paper, were first referred by Mr. Conrad to the Eocene period, in the "Journal of the Academy of Natural Sciences" for 1830. Some of these strata have been observed by Mr. Conrad on the Potomac at Fort Washington in Maryland ("Fossil Tertiary Shells," p. 30.); but the most northern which I myself examined were in Virginia, at Richmond, at Petersburg, and at several points on the James River. The formation in this region consists in great part of greensand and marl, containing green earth, so precisely like that which characterises the cretaceous strata of New Jersey, that were it not for the distinctness of the fossil shells, it would be impossible in many places to separate these deposits by mere reference to their mineral composition.

Farther south, in N. and S. Carolina, and in Georgia, the eocene formation acquires a larger development and a new mineral type, consisting of highly calcareous white marl and white limestone, and passing upwards, especially in Georgia, into red and white clays, ferruginous sands, with associated layers of burrstone and siliceous rock. This calcareous form of the eocene rocks on the Santee River and elsewhere, had led some geologists to consider the solid limestones as an upper secondary or newer cre-

taceous formation, and as forming an intervening link between the secondary and tertiary formations; but after a careful examination of several localities, presently to be described, I found the white limestone to contain exclusively tertiary fossils, without any intermixture of species belonging to the true and unquestionable cretaceous rocks of New Jersey or Alabama. It appeared to me that there was the same chasm between the cretaceous and tertiary rocks in that part of America which I visited, as has been observed in Europe generally, and those organic remains which have been supposed to be common to the two formations in the United States, have been almost all referred by mistake to the older group, in consequence of part of the white limestone of S. Carolina, which is tertiary, having been erroneously referred to the cretaceous epoch.

The largest number of eocene shells found in a good state of preservation, are those of Claiborne, Alabama, where a large collection was made by Mr. Conrad, and descriptions and figures of them were published in 1832.* At the same period, Mr. Lea, of Philadelphia, received from a friend a fine collection of the same fossils from Alabama, and referred them also to the period of the London clay of England, and calcaire grossier of Paris. In his work intitled "Contributions to Geology," he gave figures and descriptions of more than 200 species, but unfortunately, in consequence of these two eminent naturalists having laboured simultaneously, and independently of each other, almost every shell received a distinct specific name. For a list of synonyms, I may refer the reader to the appendix to Dr. Morton's "Synopsis of Organic Remains of the Cretaceous Group, Philadelphia, 1834," drawn up by Mr. Conrad.

I shall now offer a few observations on several localities of the eocene strata which I visited, beginning with the most northern, in Virginia, and then proceeding southwards to N. and S. Carolina and Georgia.

Virginia.—Below Richmond, near Coggin's Point on the James River, the *Ostrea sellaeformis* occurs in one of the uppermost of the eocene beds; and this fossil I afterwards found to be widely characteristic of the formation in S. Carolina and Georgia. At the same place, *Cardita planicosta*, so common in the London clay and Paris basin, is also found. It cannot be distinguished from one of the common varieties of the European shell, and is accompanied by an oyster very nearly allied to *O. bellovacina*. Professors W. B. and H. D. Rogers, have described and figured several of these fossils in the fifth and sixth volumes of the American Phil. Trans. for the years 1835 and 1839. Near Evergreen, on the right bank of the James River, twenty miles below Richmond, I found, in the eocene marl, a large piece of wood in a state of lignite, 7 feet long, and about 1 foot broad, bored by teredo.

* For some account of the Claiborne strata, see Conrad's "Tertiary Fossil Shells," 1842.

At Petersburg, 30 miles south of Richmond, I saw the eocene strata, containing several characteristic fossils, distinctly overlaid by a large mass of miocene shell-marl. At no other point is the older tertiary formation more remarkable for its lithological resemblance to the greensand of the cretaceous series.

North Carolina. — Very different is the aspect of the rocks near Wilmington, N. Carolina, where they consist in great part of a limestone containing siliceous pebbles, and casts of shells and corals, with many fishes' teeth. This limestone is less white and more compact than the white limestone of S. Carolina; on the shore at the town of Wilmington it is 12 feet thick, covered with a shelly miocene deposit 6 feet thick. It is quarried in the neighbourhood of the town, and burnt for lime. I obtained, besides corals, 31 species of shells, exclusive of *balani*, from this rock, almost all in the state of casts, and many of them, therefore, only capable of being named generically. Those in italics in the following list have been identified with species found elsewhere in eocene localities: —

List of Eocene Shells from the Limestone of Wilmington, N. Carolina.

Cypræa, identical with a cast from Shell Bluff, Georgia

Cypræa, two other species

Oliva Alabamensis

Oliva, allied to *O. Laumontiana* Lam. (fig. a)

Oliva

Voluta, two species

Conus

Strombus

Fusus

Buccinum, three species

Paludina, allied to *P. Desnoyerii*

Desh. (fig. c).

Natica ætites

Turritella, two species

Vermetus

Infundibulum trochiforme

Crassatella, agreeing with a cast from Eutaw

Corbula

Lucina pandata

Cardium, agreeing with one from Shell Bluff

Cardita rotunda

Cucullæa

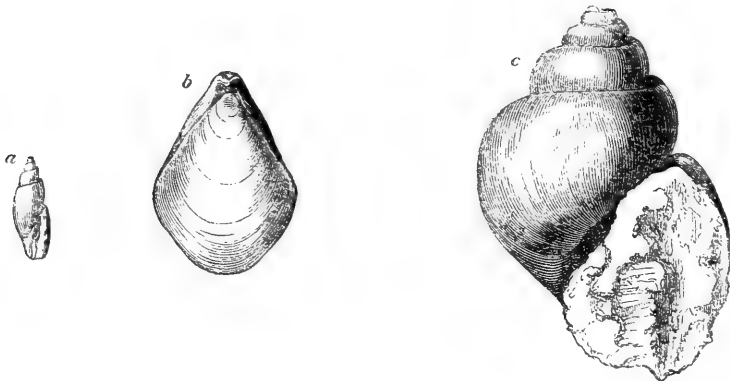
Arca, two species

Nucula magnifica

Pecten membranaceus Mort.

Terebratula Wilmingtonensis sp. n.

(*Lyell* & *G. Sowerby*) (fig. b).



a. *Oliva*, (cast,) Eocene limestone, *Wilmington*, N. Carolina.

b. *Terebratula Wilmingtonensis* *Lyell* & *G. Sowerby*.

c. *Paludina*, (cast,) *Wilmington*, N. Carolina.]

The two last-mentioned species of the above list, *Pecten membranaceus* and *Terebratula Wilmingtonensis*, alone preserve their shells, all the others being in the state of casts. The small *Oliva* (fig. *a.*), resembles in general form *O. laumontiana* Lam., or *O. nitidula* Lam., but is more slender than either. As it is only the cast of the inside, it cannot be fully described. It appears to have only two small folds in the columella, of which the anterior is the larger. The *Paludina* (fig. *c.*) is like *P. Desnoyerii* Desh. (a fossil of the white marl in the midst of the calcaire grossier), but it has six volutions, whereas the *P. Desnoyerii* has barely four and a half. In the Wilmington fossil, the spine is more acuminate and the volutions more distant, so that the suture must have been more distinct.

Terebratula Wilmingtonensis (Lyell and G. B. Sowerby), Wilmington, North Carolina. This shell resembles most nearly in general form *T. uva* Brod. (recent from the Gulf of Tehuantepec), and also approaches *T. bisinuata* Lam., a fossil of the Paris basin. The following are its characters :—

Terebratula, with an oblong, smooth shell, posteriorly acuminate, anterior margin nearly even, dorsal valve large, and posteriorly prominent.

I was informed that a species of *Nautilus* had been found in the Wilmington limestone. Among the *Polyparia* which I collected there, Mr. Lonsdale has observed the following species :—

- | | |
|---|---|
| 1. <i>Lunulites sexangula</i> Lons. | 6. <i>Dendrophyllia lævis</i> Lons., also at Shell Bluff |
| 2. <i>Lunulites</i> | |
| 3. <i>L. distans</i> Lons., also at Wantoot? | 7. <i>Caryophyllia</i> ? <i>subdichotoma</i> Lons., also at Shell Bluff |
| 4. <i>L. contigua</i> Lons. | |
| 5. <i>Flabellum</i> ? <i>cuneiforme Anthophyllum</i> of Conrad, also found at Eutaw and Cave Hall | 8. <i>Eschara tubulata</i> Lons. |

As four out of these eight corals, those in italics, and ten out of the thirty-one shells, occur elsewhere in eocene localities, I consider the age of the Wilmington limestone, on which some doubts have been entertained, as set at rest. Among the teeth of sharks in the same rock I found, together with the usual eocene forms, a species of *Galeus*. The claws of crabs are also numerous.

I observed the same formation, and some of the same shells and corals, at Rocky Point, which is about twenty miles from Wilmington, on the N. E. branch of the Cape Fear River, where a similar conglomerate occurs, with green pebbles. At some points the rock is partly siliceous, and strikes fire with steel.

South Carolina.

From the low country near the level of the sea, at the mouth of Cooper River, to the junction of the Santee Canal, and from that point to Vance's Ferry on the Santee River, a calcareous formation of the eocene period occurs. At the first point where I saw it, in Dr. Ravenel's plantation called "the

Grove," near the mouth of the river, it appears in the form of a soft pulverulent limestone, in which two species of *Scutella*, (*S. macrophora* Ravenel, and another,) are very abundant. The soft limestone had been cut through to the depth of five feet in digging a canal, situated near "the Grove," about seventeen miles north of Charleston; its thickness here is unknown. I found in it *Pecten Lyelli* Lea, a Claiborne shell, and the upper valve of an oyster, which seems undistinguishable from *O. bellovacina*; also a species of *Lucina*, and a large *Pecten* allied to *P. pleuronectes*; also a species of *Spatangus* common to the limestone of the Santee canal.

At the Rock Landing, near the Grove, the white limestone is composed of triturated shells, and assumes a very hard and solid form. It contains fragments of Echinoderms, casts of shells, and corals (*Lunulite*?): it sometimes passes into an imperfect oolite.

Between the Grove and Vance's Ferry on the Santee River, a distance of about forty miles, is a continuous formation of white limestone, which I examined in company with Dr. Ravenel, first at Strawberry Ferry and Mulberry Landing, then on the banks of the Santee Canal, and afterwards at Wantoot and Eutaw. I then followed it in a north-westerly direction for twelve miles, by Cave Hall and Streeble's Mill, to near Halfway Swamp. On reaching Stoudenmire or Stout Creek, a tributary of the Santee, we found the limestone and marl to disappear beneath a newer deposit, also referable to the eocene period, of which I shall afterwards speak as the burrstone formation.

The soft limestone varies in hardness, passing frequently into a white marl, and resembling in texture some of the *craie tufau* of the Loire in France. It consists almost entirely of comminuted shells or corals, but it rarely exhibits any laminæ of deposition, and even where it attains a thickness of twenty or thirty feet, there would be a difficulty in determining whether it were horizontal, if a bed of oysters, *O. sellæformis*, like that at Vance's Ferry, did not occasionally occur. Notwithstanding its slight elevation above the sea, the Santee limestone cannot be less than 120 feet thick at Strawberry Ferry, being vertically exposed to the extent of 70 feet on the low banks and bottom of Cooper River, and to the height of 50 feet above these banks in the neighbouring hills. Its upper surface is very irregular, and is usually covered with sand, in which no shells have been found.

At Eutaw and other points, corals of the genera *Idmonea*, *Dendrophyllia*, *Flabellum*, *Tubulipora*, *Hippothoa*, *Farcimea*, *Vincularia*, *Eschara*, and others, occur, with a species of *Scalaria*, and other shells. These fossils, and the rock containing them, reminded me so much of the straw-coloured limestone of the cretaceous formation which I had seen on the banks of Timber Creek in New Jersey, that I do not wonder that some error has arisen in confounding the tertiary and secondary deposits of the Atlantic border. The species, however, prove, on closer inspection, to be different. This lithological resemblance led to the admission into

Dr. Morton's otherwise most accurate list of the cretaceous fossils of New Jersey, of the six following species, viz. *Balanus peregrinus*, *Pecten calvatus*, *P. membranous*, *Terebratula lachryma*, *Conus gyratus*, *Scutella Lyelli*, and *Echinus inflatus* (see pl. 10., Morton's Synopsis), which came from the eocene beds of South Carolina, now under consideration, and led to a belief of the existence of a deposit intermediate between the chalk and tertiary strata, and containing fossils common to both.

One of the characteristic features of the region of tertiary white marl and limestone in South Carolina and Georgia, is the frequent occurrence of lime-sinks, or funnel-shaped cavities, arising from natural tunnels in the subjacent limestone, through some of which subterranean rivers flow. At Wantoot, there is one of these sinks in the limestone, and a spring issues from the rock so much above the temperature of the air during a frost as to send off clouds of steam.

At Cave Hall, two miles south of the Santee River, there is a cavern about twelve feet high at its opening, at the base of a precipice of limestone sixty feet perpendicular. Large beds of the *Ostrea sellæformis* occur in the limestone, which contains green particles in the lower strata. A stream is constantly flowing out of the mouth of the cave, and there is a line of sinks communicating with the underground river-course, in which the undermining process is continually going on. I was informed that a new "sink" had opened fifteen years ago within 110 yards of the mouth of the cave, and that a mule fell into the hollow while drawing the plough in the field above. Among other fossils from this place, I found in the limestone the tooth of *Myliobates*, and in the lower beds of calcareous greensand the same shells and corals as in the incumbent white limestone.

On reviewing the fossil Invertebrata which I collected from various localities in the Santee white limestone of South Carolina, I find many which will at once be recognised as species known to belong to the eocene formation of Claiborne and other places, among which I may mention *Trochus agglutinans*, *Pyrula inaurata* (*Fusus* Conrad), *Natica ætites*, *Dentalium*, same as one from Claiborne, *Lucina pandata*, *Lucina rotunda* Lea, *Lucina lapidosa*, *Crassatella* agreeing with a Wilmington (North Carolina) fossil, *Chama*, like one from Jacksonboro', Georgia, *Pecten calvatus*, *P. Lyelli* Lea, *Ostrea bellovacina*, *O. sellæformis*. Besides these we find *Terebratula lacryma*, *Ostrea Carolinensis*, *Pecten* allied to *P. pleuronectes* Lam., and shells of the genera *Nautilus*, *Voluta*, *Turritella*, *Scalaria*, *Vermetus*, *Lucina*, *Cytherea*, *Corbula*, *Cardium*, *Lima*, *Pecten*, *Ostrea*, *Terebratula*.

The Echinoderms are referable to the genera *Scutella* and *Cidaris*, and I met with several nautiliform foraminifera. The corals, already alluded to generically, will be described by Mr. Lonsdale.*

* See "Report on the Corals," &c. in the present Number of the Journal.

Burrstone Formation.

I have before mentioned that the white limestone of the Santee River, on being traced in a north-westerly direction, disappeared at Stoudenmire Creek, a tributary of the Santee, beneath a newer deposit of considerable thickness. The latter consists of slaty clays, quartzose sand, loam of a brick-red colour, and beds of siliceous burrstone, in some of which fossil sponges, having a coarse fibre, have been detected. Some of the clays break with a conchoidal fracture, and become stony when dried. One of the beds is extremely light, and resembles in appearance some kinds of calcareous tufa, but does not contain carbonate of lime. I at first supposed it to be of infusorial origin, but some practised observers have been unable with the microscope to discover infusorial cases. There were casts of shells in this rock, and in several of the associated strata, referable to the genera *Cypræa*, *Voluta*, *Natica*, *Trochus*, *Corbula*, *Mastra*, *Cardita*, *Cardium*, *Lucina*, *Nucula*, *Pectunculus*, *Pecten*, and *Serpula*. Among these, a *Corbula*, *Cardium*, and *Nucula*, seem to agree with Claiborne species; the rest did not agree with fossils from that locality, nor with those from the miocene beds of Virginia, but I was afterwards shown siliceous casts of *Ostrea sellæformis*, *Cytherea perovata*, and other eocene fossils, from strata of the same formation at Orangeburg and near Aikin in South Carolina. I believe, therefore, that the larger portion of the ferruginous sands, red clays, and white beds of kaolin (often miscalled chalk by the inhabitants of South Carolina and Georgia) belong to the Upper Eocene or Burrstone deposit.

At Aikin, fifteen miles S. E. of Augusta, and near the left bank of the Savannah River, the inclined plane of a railway has been cut through strata, 160 feet in thickness, consisting partly of earth and sand of a vermilion colour, and containing much oxide of iron; partly also of mottled clays, and white quartzose sand with masses of pure white kaolin. This compact kaolin appears fitted to make good porcelain ware. The globules of iron give a pisolitic appearance to some of the beds of quartzose sand. These beds at Aikin yielded no fossils, but I suppose them to be all referable to the Burrstone or Upper Eocene formation.

Georgia.

The same Burrstone formation is continuous from Aikin and Stoudenmire Creek, South Carolina, to Augusta in Georgia, and to the junction of the tertiary with the primary or hypogene rocks above that city. It must attain there in some places a thickness of more than 200 feet, and is very variable in its aspect and composition.

At a place called The Rocks, six miles west of Augusta, it consists of a highly micaceous quartzose grit and sand, having much the appearance of certain kinds of granite, and having been by

some writers improperly termed gneiss. The mass exhibits occasionally a distinct cross-stratification, and pieces of compact kaolin, sometimes angular, are imbedded in it. In other places, as at Somerville, red, vermilion-coloured, and white clays, 180 feet thick, are seen. These rest in horizontal beds on the edges of highly inclined strata of chlorite schist and clay-slate, which are exposed to view at the rapids of the Savannah River, three miles above Augusta. On Ray's Creek, near this point, the old schists, much charged with iron, are seen to decompose into materials so like the red vermilion-coloured clays of the tertiary deposits, that they would be undistinguishable, were it not that the veins of quartz, which have not decomposed, still remain running through them. The quartz itself, when broken up, would furnish a white sand such as that found associated with the red clays, so that we have here a most satisfactory explanation of the derivative origin of a great part of the burrstone formation.

Savannah River.—I shall now describe several natural sections which are seen in the bluffs or cliffs bounding the alluvial plain of the Savannah River, in its course of about 250 miles between Augusta and the sea. The river has an average fall of about one foot per mile, or 250 feet between Augusta and the delta of the river. Like the Mississippi and all large rivers, which, in the flood season, are densely charged with sediment, the Savannah has its immediate banks higher than the plain intervening between them and the high grounds, which usually, at whatever distance from the river, present a steep cliff or "bluff" towards it.

Near Augusta, the Savannah cuts through the red clays and sands before mentioned. Forty miles below the city, a section from 120 to 150 feet high, and half a mile in extent, is observed in Shell Bluff in Georgia, on the right bank. Unfortunately, at the time of my visit the waters were high, and covered the bottom of the bluff. The lowest exposed portion of the cliff consisted of white pulverulent marl, derived chiefly from comminuted shells, which passed upwards into a solid limestone, sometimes concretionary, and containing numerous casts of shells; and above this was again seen pulverulent white marl. Still higher, the calcareous deposit becomes more sandy and clayey, and encloses a bed of huge oysters (*O. Georgiana* Conrad), which are found growing one upon the other, and have evidently not been drifted into their present place. The total thickness of these calcareous strata is about 80 feet, above which, beds of red loam and yellow sand, such as prevail at Aikin and Augusta before mentioned, and without fossils, are seen at the top of the cliff 40 feet or more in thickness.

After a diligent search of several days, I obtained casts of no less than thirty-nine species of shells from the limestone of Shell Bluff, twenty-four of which I have been able to identify either with eocene species, known to Mr. Conrad to occur at Claiborne, or to species found by me in other eocene localities, and I have no doubt that I could have identified more had my own collection from Claiborne been more complete.

*Shells found at Shell Bluff agreeing with Species in other
Eocene Localities.*

- | | |
|--|---|
| 1. <i>Conus</i> , like one from Jacksonboro', Georgia | 12. <i>Dentalium thalloides</i> <i>Con.</i> |
| 2. <i>Cypræa</i> , like one from Wilmington, S. Carolina | 13. <i>Crassatella protexta</i> <i>Con.</i> |
| 3. <i>Oliva Alabamensis</i> <i>Conrad</i> | 14. <i>Lucina pandata</i> <i>Con.</i> |
| 4. <i>Pyrula</i> , apparently agreeing with one from Claiborne | 15. <i>Lutraria lapidosa</i> <i>Con.</i> |
| 5. <i>Voluta prisca</i> (<i>Turbinella prisca</i> , <i>Con.</i>) | 16. <i>Cytherea Poulsoni</i> <i>Con.</i> |
| 6. <i>Trochus agglutinans</i> | 17. <i>C. perovata</i> <i>Con.</i> |
| 7. <i>Melongena alveata</i> , very common | 18. <i>Cardita planicosta</i> |
| 8. <i>Infundibulum trochiforme</i> | 19. <i>C. rotunda</i> <i>Con.</i> |
| 9. <i>Natica ætites</i> <i>Con.</i> | 20. <i>Cardium</i> , like one from Jacksonboro' |
| 10. <i>Bulla</i> , like one from Jacksonboro' | 21. <i>Nucula magnifica</i> <i>Con.</i> |
| 11. <i>Crepidula lirata</i> <i>Con.</i> | 22. <i>Chama</i> , like one from Jacksonboro' |
| | 23. <i>Ostrea sellæformis</i> <i>Con.</i> |
| | 24. <i>Pecten membranous</i> |

The remaining shells, chiefly casts, which I collected, belong to the following genera: *Conus*, *Voluta*, *Turritella*, *Fusus*, *Cytherea*, *Lithodomus*, *Solenomya*, *Cardita*, *Cardium*, *Pectunculus* (two species), *Pecten*, *Arca*, *Ostrea*.

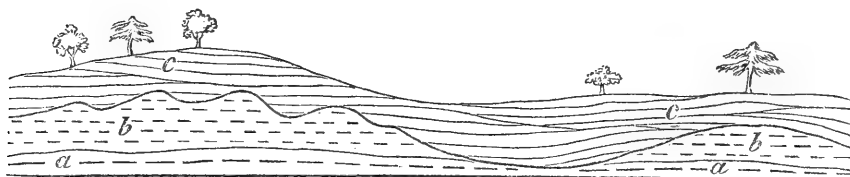
One of the species of *Ostrea*, *O. Georgiana*, has been supposed to agree with the large fossil so common in Touraine, and called by some *O. virginica*, but this identification is doubtful. The Shell Bluff species is very remarkable for its enormous thickness and length.

About nine miles below Shell Bluff, in the Long Reach, is a cliff about eighty feet high, called London Bluff, where the same shelly white calcareous beds again appear, covered with red clay and loam. The horizontal stratification is evident here, as in the cliff two miles below, where the large oysters are seen standing out in relief. Below this, at Stony Bluff in Burke County, near the borders of Scriven County, the calcareous beds have quite disappeared, and siliceous beds of the burrstone series are seen occupying the cliff, and resting upon brick-red and vermilion-coloured loam. This superposition is important, as concurring, with other facts, to show that the burrstone of this region with its eocene fossils is an integral part of that great red loam and quartzose sand formation, usually devoid of fossils, which occupies so large a space between the hypogene (or primary) region and the Atlantic. The quartzose and siliceous rock of Stony Bluff was, during the last war with Great Britain, quarried for millstones. It passes into a sandstone with distinct grains of quartz, and is full of cavities and geodes, partially filled up with crystals of quartz and agates. Portions of it are filled with spiculæ of fossil sponges, some of them in a decomposed state, and there are also seen in the same flints, when thin slices are cut and polished, minute flustriform corals and foraminiferous shells, which were detected by Mr. Bowerbank, who has had the kindness to examine the specimens for me micro-

scopically. Loose flints of this formation, containing spines of echini and other fossils, are scattered over the surface of the country, like chalk-flints in England. At Millhaven, in Scriven County, about eight miles from Stony Bluff, and five in a direct line from the Savannah River, the siliceous beds crop out on the banks of a small stream. In the flints here I found casts of several shells of the genera *Valvata*, *Pecten*, and *Terebratula*, with a species of *Cidaris*. It was evident to me that this millstone belongs to the same formation of red loam and sand which extends almost uninterruptedly from Aikin and Augusta to this region, for I observed near Millhaven, where the deposit has been pierced through to the depth of 26 feet in wells, pieces of white kaolin embedded, like those before mentioned near Augusta.

Jacksonboro', Scriven County.

SECTION OF EOCENE STRATA ON THE RIGHT BANK OF BEAVERDAM CREEK, SCRIVEN COUNTY, GEORGIA.



a. Limestone. b. White marl. c. Yellow and red sand and clay of the burr-stone formation.

About eight miles from the Savannah River, and one mile west of Jacksonboro', a limestone occurs, covered with sand, in the fork of Briar and Beaverdam Creeks, which has been quarried for lime. This limestone (*a*) passes upwards into marl (*b*), which has an undulating surface, as represented in the annexed section, and appears to have been denuded before the deposition of the incumbent sand and loam (*c*). The height of the cliff is about 25 feet, the thickness of the calcareous formation varying from 10 to 15 feet, and the yellow sand which rests upon it from 3 to 10 feet.

From this limestone of Jacksonboro' I obtained, besides corals and echinoderms, thirty species of shells, the larger portion of which were kindly presented to me by Colonel Jones of Millhaven. Those in italics agree specifically with fossils from Claiborne, Alabama, or other eocene localities, which I have specified.

Fossil Shells of Jacksonboro', Scriven Co., Georgia.

Oliva Alabamensis

Voluta prisca

Conus, same as one from Shell Bluff

Rostellaria or Strombus (casts), four species

Fusus inauratus

Cerithium Georgianum Lyell & G.

Sowerby, see fig. ?

Melania, see fig. ?

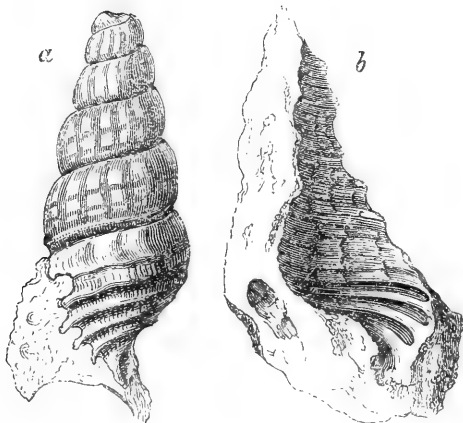
Paludina ?

Natica ætites
Turritella
Bulla, same as one from Shell Bluff
Trochus agglutinans
Infundibulum trochiforme
Solarium canaliculatum
Dentalium
Crassatella
Lucina pandata
Cytherea

Cardium, like one from Shell Bluff
Chama, like one from Shell Bluff
Cardita
Lithodomus dactylus
Modiola
Mytilus
Avicula trigona ?
Pecten
Ostrea panda



c. *Melania*, cast.



Cerithium Georgianum.
a. Nucleus. b. Cast of exterior.

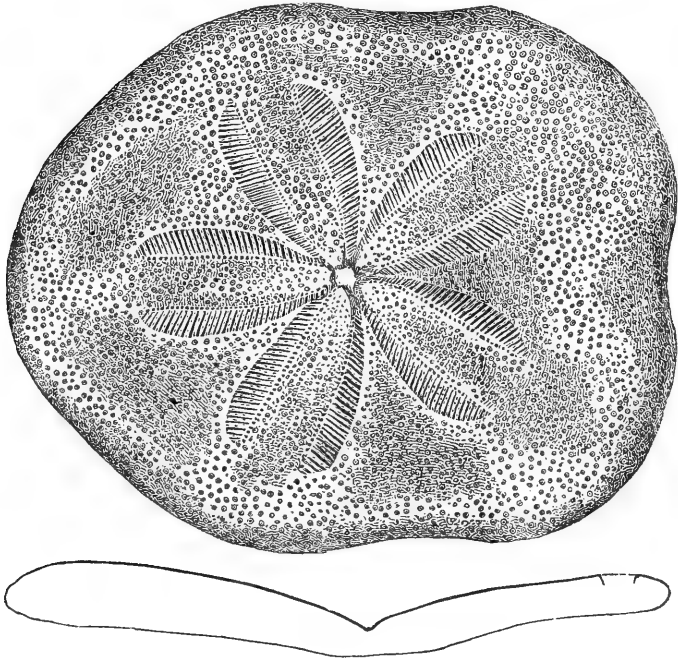
The shell named *Cerithium Georgianum* in the above list (figs. a, b.), is very abundant, and closely resembles *C. lamellosum* Lam., a tertiary species of the Paris basin. Its characters are as follows :—

Cerithium, with an acuminate turreted shell, volutions 9 or 10, rounded, with rather obsolete and irregular longitudinal ribs, and with 5 or 6 transverse ridges, of which the three anterior are very prominent, and lamellose near the aperture.

Of the next shell in the list, named *Melania* (fig. c.), there is only a cast of the inside preserved, so that its external characters cannot be distinctly known.

Of the *Lithodomus dactylus* I obtained a beautiful cast, both of the exterior and interior, from the cavity of a fossil coral. It resembles the West Indian variety, and is an eocene species well known in the Paris basin. As, according to Philippi, it is one of the most cosmopolitic of living species, we have the less reason to be surprised at its great vertical range in the geological series.]

A species of *Scutella* differing from those found by me in other places was common at Jacksonboro'. For the following description of it I am indebted to Professor E. Forbes, and it has been named, after Colonel Jones of Millhaven, *Scutella Jonesii* :—



Scutella Jonesii Edward Forbes.

Body plane, shield-shaped, subpentangular, with sides and posterior margin undulated; angles obtuse.

Back centrally slightly convex, interambulacral spaces depressed; ambulacral spaces broad, somewhat convex, with parallel sides. *Avenues* petaloid, with their inner margins nearly straight. Pairs of pores in each avenue 37, united by oblique lines.

Oral surface concave, with five deep furrows radiating from the mouth to the margin.

Margin thick, rounded.

Lat. $2\frac{1}{12}$. lon. $2\frac{10}{12}$. crass. max. $\frac{4}{12}$.

This species appears to have been marked with spots.

Locality.—Jacksonboro'.

I have no doubt that all the sandy soil on which the long-leaved pitch pine grows in the neighbourhood of Jacksonboro' belongs to the burrstone formation, consisting of sand, ferruginous sandstone, and red loam, and although it is rare to find the limestone and marl exposed to view, I believe it to be everywhere subjacent. For we meet not unfrequently in Scriven, and several of the adjoining counties, with lime-sinks, or deep depressions, more or less circular in shape, in the vertical walls of which we observe sections of the horizontal beds of sand and mottled red and yellow loam and clay. As the water does not stand in these sinks, there is evidently a subterranean drainage, by which the loose sand has been carried down, and the surface undermined, as before described at Cave Hall. I saw several lime-sinks near Jacksonboro', and one about 16 miles south of Millhaven, on the east side of the road to Savannah, at Reeve's mill. It was 60 paces in circumference, and 80 feet in depth, and the beds gone through consisted of yellow and deep-red sand, in some parts ferruginous, with beds of mottled red and white steatitic clay.

All the bluffs which I examined on the Savannah River below Briar Creek belonged to the beds above the limestone, and are referable for the most part, if not entirely, to the burrstone formation. I observed several sections in the Long Reach in Scriven's County, where the red loam and yellow sand is conspicuous; and there is a fine section in Hudson's Reach, at a place called Tiger-Leap, where beds of fuller's earth occur. A few hundred yards below Tiger-Leap, where a small creek or brook enters on the right bank of the Savannah River, I found in some of the white clays impressions of *Macra*, *Pecten*, and *Cardita*, with fragments of fishes' teeth, particularly of the genus *Myliobates*, several of the genus *Lamna*, and one of the genus *Galeus*. These bluffs of loam, clay, and sand are often 80 feet in height; and after passing Scriven I found, in the county of Effingham, similar sections, as at Sister's Ferry and Ebenezer. In the section at Sister's Ferry there is not only the brick-red loam, and the red and grey clay and sand, but layers of steatitic clay, which, although soft when moist, become hard and acquire a conchoidal fracture when dried.

On the whole it appears, from the information I obtained, that the less elevated part of South Carolina and Georgia, intervening between the mountains and the Atlantic, has a foundation of cretaceous rocks, containing *Belemnites*, *Exogyra*, and other fossils, above which are, first, eocene limestones and marls, and, secondly, the burrstone formation, with its red loam, mottled clays, and yellow sand. I am informed by Mr. Vanuxem that a tertiary lignite formation is sometimes interposed between the cretaceous beds and the eocene limestone; but I had no opportunity of verifying this fact in the sections which I saw, partly, I believe, owing to the swollen state of the rivers at the time of my visit. The remarkable difference of the fossils found in the eocene limestone at different points may lead some to the suspicion that there exists in this country a considerable succession of minor divisions of the eocene period, but I am inclined to ascribe the circumstance principally to two causes: first, that the number procured in each place is small, and therefore represents a mere fraction of the entire fauna of the period under consideration; and, secondly, that we have not yet any great eocene collection from any part of the United States. If we had 1000 shells from Alabama instead of little more than 200 (those, namely, which have been found at Claiborne), we should be able to form a more correct opinion respecting the mutual relations of the strata at distinct points, such as Shell Bluff, Jacksonboro', Eutaw, the Santee canal, and Wilmington, North Carolina.

The difficulty of classifying the tertiary strata of the southern states arises mainly from the wide extent of red and white clays, and siliceous sand, without fossils. The sterile sands which form the soil of the pine barrens in the lower plains of Virginia and North Carolina appear to belong to the miocene period, while those of a large part of South Carolina and Georgia are eocene. Some of the red ochreous and vermilion clays, as, for example, those of Martha's Vineyard and at Richmond, Virginia, are mio-

cene. Others of similar character in South Carolina and Georgia, as at Orangeburg, Aikin, Stony Bluff, and Millhaven, belong to the burrstone formation, which is of the eocene period.

The species of eocene shells common to the United States and Europe appears to be very small. I have in my cabinet eighty-five species, in a good state of preservation, from Claiborne, Alabama, presented to me by Mr. Conrad; and I procured from the various localities already enumerated in this paper about forty species which I could not identify with the above, or with any which I have seen from Claiborne. Out of these 125 species I have been able to identify the following seven only with European eocene shells: namely, *Bonellia terebellata*, *Trochus agglutinans*, *Solarium canaliculatum*, *Infundibulum trochiforme*, *Cardita planicosta*, *Lithodomus dactylus*, *Ostrea bellovacina*. The proportion, therefore, of species common to Europe and the United States scarcely exceeds five per cent., and the proportion of species now living and identical with the American eocene shells appears to be still smaller. In regard to geographical representations, I found at least one fourth of the species to be very closely allied to European eocene fossils, while another fourth presented forms differing greatly from any species procured from the eocene strata of Europe, although belonging to genera which are abundantly represented in these formations.

March 12. 1845.

Sir Robert Burdett, Bart., of Ramsbury Park, Wilts, and Warrington W. Smith, Esq. M.A. of Trinity College, Cambridge, were elected Fellows of this Society.

The following communication was read:—

On the comparative Classification of the Fossiliferous Strata of NORTH WALES, with the corresponding deposits of CUMBERLAND, WESTMORELAND, and LANCASHIRE. By the Rev. ADAM SEDGWICK, M.A., F.R.S., Woodwardian Professor of Geology in the University of Cambridge.

THE author referring to his memoir on the structure of North Wales, published in the first number of this Journal, for an account of the sequence of the rocks in that district, states that his object now is to bring the successive groups of the Cumbrian mountains into comparison with the three primary divisions of the whole Welsh series.*

* These divisions are:—

3. The uppermost slate rocks of the Upper Silurian age, consisting of a series of beds called by the author the '*Creseis* flagstone,' from the abundance of that fossil, overlaid by the Denbigh flag, &c.

2. Roofing slate and greywacke of great thickness, with alternating beds of contemporaneous porphyry.

1. Chlorite and mica slate, &c. of Anglesea and the S. W. border of Caernarvonshire.

The whole series of the Cumbrian slates, like that of North Wales, has been considered to admit of three primary divisions, but hitherto the separation has been chiefly made from a consideration of physical characters and superposition, and without reference to fossils; the uppermost only of the three being supposed to contain them. In this state the author left his maps in 1824, and they show the superficial extent of the igneous and intrusive rocks, of the lowest or Skiddaw slate, of the great mountain masses of green roofing slate and porphyry, alternating in vast parallel bands, and lastly, of the fossiliferous slates extending from the Coniston limestone to the highest beds on the banks of the Lune, near Kirby Lonsdale.

Of these beds the author considers that the Skiddaw slate has, perhaps, no true equivalent in N. Wales, and that the green slates and porphyries are probably the exact representatives of a portion of the great system of Snowdonian slates. The Snowdonian slates, however, contain fossils, and the green slates and porphyries of Cumberland are without them; a difference accounted for as the consequence of the greater abundance of igneous rocks among the green Cumbrian slates. It remains then to find the equivalent of the fossiliferous rocks in the third and highest division of the Cumbrian slates, and for this purpose the author discusses in its most limited form the following questions, namely:—Into what groups may we subdivide the slates expanded between the Coniston limestone, and the highest beds of the series on the banks of the Lune, near Kirby Lonsdale? and what are their equivalents in North Wales? Professor Sedgwick considers that, with the exception of the Coniston limestone, and two or three hundred feet of slate and shales surmounting it, the whole of the upper series is *Upper Silurian*, and in the parallel of the Denbigh flagstone, using this latter term in its most extended sense.

The author then enters into some detail with regard to the actual working out of the geology of this district, and his ultimate discovery that a great movement of the strata had brought up the Coniston limestone a second time, on the south side of the estuary of the Duddon, in a ridge called High Haulme, N. W. of Dalton in Furness. In this ridge the beds are nearly vertical, and are associated with trappean rocks and porphyries exactly like those under the Coniston limestone on the north side of the Duddon, which are several miles distant.

The calcareous bands of this ridge being nearly in the same line with a second or higher band of limestone, became confounded with it, and this has led to a wrong estimate of the geological equivalents of the second band of limestone. The mistake being corrected, it appears that the successive groups of strata will easily fall into their right places without the intervention of any great unconformable overlap. Thus the fossiliferous slates present—first, the Lower Silurian rocks in a very degenerate form; and secondly, the Upper Silurians in a noble series, more complete and far thicker than the Denbigh flagstones, and ending with the red flags or tile

stones of the Lune. The author then proceeds to describe some of the lower groups of these rocks and their fossils.

1. *The Coniston limestone.* Most of the points of interest with regard to this bed have been described by the author in a former paper, of which an abstract has been given in the Proceedings of the Geological Society.*

It is of a dark blue colour, traversed occasionally by contemporaneous white calcareous veins, and its colour appears to be derivable from metallic oxides and not from carbon, as it burns to a dark-coloured lime, which is used for agricultural purposes, and as a cement stone. This limestone sometimes immediately overlies felspar rock and porphyry, and the bottom beds, although generally impure and siliceous and occasionally slaty, contain in some places 20 or 30 feet of beds fit for use. In Long Sleddale, however, a singular trappean rock with great balls of agate underlies the limestone, and in Kentmere the lower beds contain masses of coarse conglomerate; and although this is rare, yet as a general rule these beds exhibit no marks of metamorphosis, and the green slates and bedded porphyries below are so parallel to the limestone, that all have evidently been disturbed together, while the passage from the lower beds to the upper is almost instantaneous.

The limestone bands are variable in their character, and not strictly continuous, and the best beds are generally only a few feet thick. On one side of Long Sleddale they are good, on the other very degenerate, and occasionally they only form irregular rognons in a dark fossiliferous slate. Above the limestones are shales and soft slates, pyritous at the division of the beds †, and generally of dark colour; in these the rognons disappear gradually, but the fossils ascend into them for some distance. At Sunny Brow the slates are harder but too much jointed to be worked: at Ash Gill, however, they are extensively quarried and contain many fossils, one or two of them new species, but of Lower Silurian types. The thickness of this group, which terminates the Lower Silurian series, is probably upwards of 300 feet.‡

* Proceedings, &c., vol. i. p. 249.

† In consequence of this appearance, unsuccessful attempts have been made to obtain copper from these beds, but small veins and strings of sulphuret of copper have been partially worked to the east of Coniston.

‡ The author appends the following observations concerning the fossils of the Coniston limestone.

The Coniston limestone seems to contain all the characteristic fossils of the Llansaintfraid section combined with many of the Bala species. The following is the list of species:—

Polyparia.

Astrea, one or two species	Stromatopora concentrica
Favosites polymorpha	Turbinolopsis bina
F. spongites	Retepora, scattered pores of a large
F. fibrosa	species
Porites pyriformis, in abundance, and	Catenipora escharoides
a nearly allied species of larger size	Tentaculites annulatus
P. inordinata	Tentaculites, a new species

2. *Coniston flagstone*. This group the author has formerly described as *Brathay flagstone*, but now proposes to change its name to *Coniston flagstone* for the sake of symmetry. No group is better defined than this in the Lake country, and although the Brathay and Coniston quarries are several hundred feet above the preceding group, the series may be completed, in consequence of the regularity of the dip, by connecting a succession of quarries, and in this way the whole is estimated to be not less than 1500 feet thick.

The mineral character of the Coniston flags resembles that of the lower Denbigh flags, but is more altered by slaty cleavage *,

Mollusca.

Orthoceras, three smooth species, like those from the lower Bala limestone	<i>Orthis vespertilio</i> <i>O. virgata</i> <i>O. actoniæ</i>
<i>Lituites cornu-arietis</i>	<i>Orthis</i> n. sp. (named in MS. <i>crucialis</i>), perhaps two species under the same name
<i>Euomphalus</i> ?	<i>O. radians</i>
<i>Turritella</i> , or <i>Terebra</i>	<i>Orthis</i> n. sp. ? with fine simple ribs
<i>Turbo</i> ?	<i>Orthis</i> n. sp., same as from Dudley, a curious rough species
<i>Leptæna depressa</i>	<i>Atrypa</i> (<i>Spirifer</i>), resembling <i>S. acuminata</i>
<i>L. n. sp.</i> , decussated	<i>A. (Spirifer)</i> , a smooth species, ? new
<i>L. sericea</i>	<i>Atrypa affinis</i>
<i>L. transversalis</i> and another	<i>Spirifer</i> n. sp. named in MS.
<i>L. (Orthis) grandis</i> , Sil. Syst.	<i>S. n. sp.</i> ? small variety of <i>S. radiatus</i>
<i>Orthis canalis</i>	
<i>O. alternata</i> ?	
<i>O. testudinaria</i>	
<i>O. flabellulum</i> β	

Crustacea.

<i>Cytherina lævigata</i>	<i>A. tyrannus</i>
<i>Paradoxides quadrimucronatus</i>	<i>Illænus (Bowmanni)</i> , MS.; called <i>Bumastus Barriensis</i> in a former list)
<i>Calymene Blumenbachii</i>	<i>Brontes</i> , undescribed species (<i>vide</i> Portlock's report).
<i>Calymene</i> n. sp.	
<i>Asaphus Powisi</i>	

The corals, both as to species and numbers, are precisely similar to those north of the Berwyns.

In the abundance of *Leptæna depressa*, *L. transversalis*, *Orthis radians*, and above all, *O. inflata*, with spiral shells, and *Lituites cornu-arietis*, there is an analogy with the beds north of the Berwyns: but the presence of *Orthis Actoniæ* and *O. virgata*, with *Spirifer (crucialis)*, which are also plentiful, approximates the group to that from Bala and the Coniston limestone; it resembles also these latter beds in possessing the smooth *Orthoceratites*, *Encrinites*, and *Illænus (Bowmanni)*, but it differs in the scarcity of *Orthis canalis*, *O. testudinaria*, and *O. vespertilio*, and the absence of *O. flabellulum*, *O. alternata*, *Spirifer radiatus*, *Agnostus pisi-formis*, *Trinucleus Caractaci*, and *Asaphus tyrannus* (one doubtful specimen of this latter having been found), fossils characteristic of the lower group in Wales.

An undescribed *Paradoxides*, a tail of a new *Brontes*, a curious undulated fossil (perhaps crustacean), a new *Tentaculites*, and abundance of *Cytherina* (a marine *Cypris*) seem peculiar to the Coniston limestone; and the last is a very interesting fossil, not having been known before in rocks of the Silurian series.

* The author observes, with reference to this condition, that he has observed in the flags in question distinct cases of a second cleavage plane entirely distinct both from joints and bedding.

and is chiefly made up of a dark coloured coarse slate or flagstone, through which are distributed rounded concretions, (sometimes spoiling the slate,) in which, as well as in the colour and bedding of the rock, in the presence of small calcareous veins, and the appearance of a great bedded mass of ripple marked flagstones without slaty cleavage at the top of the group, there is seen a near resemblance to the Denbigh flags. In the upper flags just alluded to, there are also (in the gill above Hawkshead Fould) calcareous masses and lenticular beds of limestone not fossiliferous, and probably not continuous, and therefore not considered by the author as forming a second band of limestone.

The Coniston flags thus characterised extend from the extremity of Shap Fell to the top of the Duddon Estuary, and might readily be laid down on a good map. It only remains, therefore, to determine their relative position from the included fossils.

In the Brathay quarries were found *Graptolites ludensis* in considerable abundance, and at another locality, within a few hundred feet of the Coniston limestone, *Atrypa compressa* was also plentiful, and was accompanied by a *Creseis*. At Cold Well, considerably above the Brathay quarry, appeared *Asaphus caudatus*; and at Kent-mere in the same group *Astrea ananas*, *Creseis* being distributed throughout. All these fossils occur in the Wenlock shale, or Lower Denbigh flag. The author therefore concludes that the series in question represents the Lower Denbigh flagstones, and is the equivalent of the Wenlock shale.

3. *Coniston or Furness Grits*. This name is given to a group of bluish grey grits of great thickness, and very highly inclined, overlying the Coniston flags. It is on the whole a well defined group; but at its N.E. end is broken up by the interpolation of slaty bands, and loses its well defined mineral type. It may, however, be distinctly traced, and laid down on a map, from Bannisdale Head to Broughton; occupying a zone, on the average, more than half a mile wide. No fossils have as yet been discovered in it, but the author brings it into comparison with some hard grits which alternate with the lower Denbigh flags, north of the Holyhead road; he does this however only for the purpose of exhibiting analogies of structure in rocks of nearly the same epoch.

4. *Ireleth Slates, &c.* This is described as a great group possessing a considerable unity of character, and characterised by rocks with a good slaty cleavage distinct from the bedding, the slates being sometimes good enough for quarrying, and alternating with gritty bands, some of them very coarse, and rarely passing into a conglomerate form. The beds of this group are greatly contorted through their whole range, and especially at their north-eastern and south-western ends, and the thickness of the whole is very difficult to determine justly. For convenience of description, the whole series is separated by the author into three divisions, namely:—

a. *The Lower Ireleth slates*, a band of considerable width, made up of beds dipping at high angles, and steadily to the S.E. Being

seldom contorted, these beds must be of great thickness. They produce workable slate, but no distinct fossil species have yet been found in them.

β. A thin zone of *calcareous slate with concretions of limestone*. This bed is only a few feet thick, and the *rogkons* of limestone are sometimes replaced by a singular cellular calcareous slate with obscure casts of fossil shells. It ranges on the south of the Duddon, and has been traced from point to point; and after an interruption of two or three miles it appears at Tottle Bank heights, from which it may be traced over the neighbouring hills to a spot below Low Hall farm on the east side of Coniston water. A third obscure band of limestone is stated by the author to exist in the hills north of Nibthwaite.

The fossils of these bands of limestone are Upper Silurian; but though numerous they are very obscure.* In his letters on the lake district, the author states that he has described these fossils as Lower Silurian; but the specimens alluded to were obtained from High Haulme, three quarters of a mile S.E. from Ireleth village. "The limestone there forms a ridge not exactly continuous with the other limestone, which I accounted for by the interposition of a fault. But there is no fault of the kind I supposed. The High Haulme limestone is an independent ridge, the limestones and the slates are vertical, and associated with great masses of felspar rock and porphyry, exactly like the older slates below the Coniston limestone, and when brought up against the newer series of slates, these latter are thrown into most extravagant contortions."†

γ. The third subdivision of the great complex slaty group here described is termed by the author the *Upper Ireleth slates*, and exhibits remarkable examples of structure. These beds contain round concretions, like those of the Coniston flags. They are of great thickness, and alternate with beds of grit passing into coarse sandstone, and, rarely, into a conglomerate. Following them from Ireleth, where they are largely worked, to the Leven sands, they gradually pass into a coarser deposit without any regular line of demarcation. These coarser beds also contain concretions, and, though unfit for use, they continue to show a striped surface and slaty structure.

* The author adds in a note, "The enormous dislocation which throws forward the Coniston limestone at the Water Head seems to affect the whole chain of hills to the bottom of the lake. The corresponding beds on the opposite sides of the lake are not in the prolongation of the lines of strike. The lake therefore occupies a line of fault, on the eastern side of which is an enormous upcast of the whole series of rocks."

† The following is a list of the fossils collected at High Haulme from the dislocated Coniston limestone:—

Cyathophyllum
Catenipora escharoides
Favosites fibrosa, and other species
Retepora, very large
Porites pyramiformis
Astrea

Turbinolopsis bina
Spirifer crucialis
Orthis Actoniæ
—— canalis
—— inflata
Calymene Blumenbachii.

This group may be traced to Shap Fells and Bretherdale, parallel to the lower beds; and in the hills composed of it on the sides of Kentmere, Long Sleddale, &c., several fossils were obtained, of which the following is a list:—

Leptæna lata.	North end of Potter's Fell, Helme Park, &c., Underbarrow.	
Orthis lunata.	Ditto	Ditto.
Spirifer? (S. octoplicatus of Mr. Sharpe's paper.)	Ditto	Ditto.
Terebratula navicula (plenty).	Ditto	ditto.
Avicula retroflexa.	Ditto	ditto.
Cornulites serpularius.	Ditto	ditto.
Turritella conica.	Underbarrow.	
Ophiura n. sp.	Potter's Fell.	
Orthoceras ibex.	Helme Park, &c., Howgill.	
	&c.	&c.

5. *Group of coarse Slates, Flags, Grits, &c.*—The author has already noticed this group as a coarse development of the Ireleth slates, and the beds have been named by Mr. Sharpe, *Windermere rocks*. They are so far important that they are of great thickness, and pass downwards into the Ireleth slates. Upwards, they blend themselves insensibly with the sixth group; the singular slates, grits, and flagstones which commence a few miles north of Kendal, and continue southwards over the moors as far as Kirby Lonsdale, ending in red slaty beds like the tilestone of Shropshire, the geological place of which these slaty beds occupy.

The group now under consideration is greatly broken and shattered by faults, but no part of it can be considered non-fossiliferous, as the author found *Cardiola interrupta* in the very heart of it, and fragments of encrinites elsewhere.

The author is not aware of any evidence of want of conformity between the beds of this group and the other masses.

6th *Group, nearly on the parallel of the Upper Ludlow.*

The author is inclined to place the base of this group near Underbarrow, whence to the limestone of Kendal Fell there is a magnificent section. The fossils are very numerous, and some are peculiar to the neighbourhood. *Terebratula navicula* is only found in the lower part, but the whole upper part is full of fossils, the prevailing type being Upper Ludlow, although amongst these beds is a remarkable band with *Asterias*.

A great downcast fault in the valley of the Kent affects these beds, and on its south side is seen the "tilestone," separated from the other rocks by singular calcareous shales.

The siliceous, flaggy, and gritty beds of the Upper Ludlow are then carried with many breaks and undulations to the valley of the Lune, where they are overlaid by a thick mass of tilestone.

The uppermost beds of this tilestone are full of fossils, all of Upper Silurian species; and there is, in the opinion of the author, no true passage from the tilestone to the overlying old red sandstone.*

* The author's opinion seems to be grounded on the three following facts:—

(1.) As a general rule the conglomerates of the old red sandstone are perfectly unconformable to the upper slates of Westmoreland: of this there are many undoubted examples.

The author next alludes to the rocks of Howgill Fell and Ravenstonedale on the east side of the valley of the Lune; and he considers that these rocks, which offer considerable difficulties in their accurate determination, though separated by great faults from the higher parts of the Upper Ludlow series, are not to be considered as unconformable to that series, and probably contain a portion of it in their great folds and undulations. Through the eastern boundary of the district in which they occur, ranges the great Craven fault, described by the author in a former paper; and he has found, brought up apparently on one side of the fault, and appearing in the hills between Dent and Sedbergh and between Sedbergh and Ravenstonedale, a series of calcareous shales containing fossils, which mark the date of the series as not far from the parallel of the Coniston limestone; but he believes with Mr. Sharpe, that the greater part of Howgill Fells is made up of the coarse gritty Upper Silurian beds between the Ireth slates and the Upper Ludlow rocks.

Returning then to the comparison which was the great object of his communication, the author states as his general result, —

1st. That the chlorite and mica slates of Caernarvon and Anglesea have no parallel in Cumberland, being of a distinct epoch from the other rocks in the district, and evidently older. The same cannot be said of the metamorphic and crystalline rocks of Skiddaw forest, which rest on the granite, and pass gradually into the coarse Skiddaw slate. These may have assumed their present structure after the epoch of the Skiddaw slates.

Of the Skiddaw slate also, the author finds no exact representative in North Wales. It is not traversed by contemporaneous beds of porphyry, &c. Though composed of a fine, dark, glossy clay slate alternating with coarse bands, (sometimes, though rarely, passing into very coarse grit,) and though containing in one or two places a quantity of carbonaceous matter, it does not effervesce with acids, and no fossils have yet been obtained from it. Should fossils be discovered in it, they must belong to some of the oldest Protozoic types of our island.

2. That the green slates and porphyries of Cumberland cannot be separated from the rocks of the same mineral structure in Snowdonia. One, however, contains bands of fossils, and the other does not. The porphyries abound so much in Cumbria, that organic beings were unable to exist among them, or their remains have become obliterated.

3. The Coniston limestone represents the top of a series which passes into the *Creseis* and *Graptolite* flagstone, and so also does the Llansaintffraid limestone. The list of fossils from these two groups is also nearly identical, and they both contain some Wen-

(2.) The beds of old red conglomerate on the Lune are not exactly parallel to the beds of "tilestone."

(3.) The conglomerates contain many fragments of the "tilestone," which must have been solid before the conglomerates were formed.

lock fossils and shells. Hence the Coniston limestone does not represent the great limestone east of Bala Lake.

4. The Upper Silurian beds form a very distinct system or group of formations, and the lowest division of the system seems to coincide exactly with the lower Denbigh flags. In all other parts of the upper series there are only analogies of structure, and the groups do not physically represent the groups of the same system in Siluria proper. The upper groups in Westmoreland are more largely developed in North Wales, and contain a fine tilestone, and so far they conform to Mr. Murchison's types.

5. The list of fossils taken as a whole conforms also very exactly to the Upper Silurian lists of Mr. Murchison, but the distribution of the species is very different, because the physical conditions of the deposit were different.

Between the distribution of the species in the upper system of Wales and Cumberland there is a close analogy, because the conditions of deposit were, especially in the lower part, very analogous.

6. The fossils of the lower or Protozoic system form but one group, although some species are found in the Coniston and Llansaintffraid bands which do not appear in the lower beds, and *vice versâ*, and the fossils disappear altogether in descending order.

The author promises to resume the subject, and to give fuller details, and a more copious list of fossils, in a future communication.

April 2. 1845.

The following gentlemen were elected Fellows of this Society :—
Waller A. Lewis, Esq., B.A., Capt. Washington, R.N., Albenmarle Bettington, Esq., Robert Stephenson, Esq., George Stephenson, Esq., Lieut. Baird Smith of the Engineers, Capt. Thomas Hutton of the Bengal Army, John McClelland, Esq., of the Bengal Medical Service, and the Earl of Auckland.

The following communications were read :—

1. *On a supposed AEROLITE, said to have fallen near LYMINGTON, HERTS.* By R. A. C. AUSTEN, Esq., F.G.S.

IN this communication the author described a fragment of stone supposed to have fallen from the air, and stated the evidence on which the supposed fact of its being an *Aerolite* was founded.

2. *On the Junction of the Transition and Primary Rocks of CANADA and LABRADOR.* By Capt. BAYFIELD, R.N., F.G.S.

THE country to the northward of Lakes Superior and Huron, and of the St. Lawrence River and Gulf, is for the most part a wilder-

ness of primitive or granitic rocks. These rocks, from the northern shores of the two lakes just mentioned, pass close to the northward of Lake Simcoe, and are met with in ascending all the streams tributary to the Rice Lakes, and to Ontario from the north. Sending off a spur to the southward, they are seen at the N. E. extremity of the last-named lake on the immediate shore of the St. Lawrence, which they cross some miles below, forming many of the Thousand Islands, and uniting with the primary region in the northern part of the state of New York.

From Kingston and the Thousand Islands the primitive beds may be traced to the N. E., until they cross the Ottawa River near Lake Chât. Thence, continuing in the same direction, they form the northern side of the valley of the St. Lawrence, and the rapids and falls a few miles up its tributary streams, till they abut upon that river at Cape Tourment, nine or ten leagues below Quebec. From the point last designated, the granitic rocks continue without interruption to form the northern shore of the St. Lawrence river and gulf to the strait of Belle Isle.

To the southward of this wild country, inhabited only by fur-traders or scanty bands of roving Indians, succeeds one of comparative fertility, which it owes principally to the presence of transition rocks, or to the beds of clay and sand that frequently overlie them, and which, in some cases, have been found to belong to the newer pliocene or post-pliocene era.

The object of the present memoir is to trace very generally, but accurately, as far as it is yet known, the line of junction of the fossiliferous transition strata just alluded to, with the primary rocks on which they repose; to point out briefly the fossils and minerals which have been found in each; and to offer such inferences as may fairly be drawn from the cursory examination of a region of such wide extent. It is only the rough outline, and so far as regards the northern district, which is here attempted; the filling up of the picture in all its details, notwithstanding the great progress made by the American geologists, and recently by Mr. Lyell, must be the work of years and of many hands.

Commencing from the extreme west of the line which has been indicated, the magnificent Lake Superior first claims attention. Referring for a description of its rocks and minerals, as far as they are yet known, to the first volume of the Transactions of the Literary and Historical Society of Quebec, it will be sufficient here to notice very generally its principal geological features. The height of land surrounding this immense lake, and on which its numerous tributary streams have their sources at an elevation not exceeding 700 feet above the lake, may be considered as forming an irregularly oval basin, and is every where composed of primitive rocks. The highest hills do not rise beyond 2000 feet above the lake, whose surface is 623 feet above and its extreme depths perhaps as far below the tidal waters of the Atlantic. Primitive rocks form much of the steep and mountainous north coast, and are also occasionally seen on its southern shore. They consist of various granitic compounds,

almost always containing hornblende, either as a fourth constituent mineral, or as replacing the mica. Frequently the mica and quartz are both absent, and the rock becomes a syenite, which, by a gradual diminution of its felspar, passes into crystalline greenstone, and whilst in some parts there is thus a complete passage from granite to greenstone, in others the different varieties alternate in immense beds, whose general direction is to the N.E. Basaltic dykes, often of enormous size, traverse these beds, sometimes passing from one to another unaltered, and ranging up the hills for miles.

Associated with these rocks, penetrating them in veins and dykes, or reposing on them, are various trap-rocks, occurring on both sides of the lake and on its islands, but most extensively developed on the northern coast. They consist of various porphyries and amygdaloids, syenites, greenstones, and basalts, the last being occasionally prismatic, with pitchstone in thin layers between the interstices of the columns. Many of these rocks pass into each other, forming endless varieties.

In the primitive rocks, besides the usual constituent minerals, including hornblende, we find schorl, garnet, amethyst and rock crystal; epidote and purple fluor spar associated in veins of quartz in granite; chlorite and green earth, with calc-spar in veins, in granitic and greenstone rocks; sulphate of barytes, with fluor and calcareous spars in a vein of greenstone. The magnetic black and brown oxides of iron, specular and micaceous iron, and iron pyrites, occur abundantly; copper pyrites rarely, in veins in greenstone.

The trap-rocks are rich in minerals. I noticed calcedony, carnelian, jaspers, various and beautiful agates, zeolites (mesotype and stilbite), epidote, augite, olivine, green-earth, fibrous prehnite, fluor-spar, satin-spar, calc-spar, amethystine quartz, and felspar crystals; graphite, and the oxides of iron before mentioned; also copper pyrites, malachite, and native copper. The last occurs, with prehnite, quartz, and calc-spar, in veins in a dark brown porphyritic trap; also in amygdaloid in veins, nests, and wires, which sometimes penetrate fortification agates.

Reposing on the granitic rocks which have been mentioned, there occurs a horizontal sandstone, forming nearly the entire southern shore of the lake, which may be traced in detached portions from one end to the other of its northern shore, and also on most of its islands; the almost unknown Caribou Island, which is so far from the shore that it can only be seen from the mountains in a clear day, being also formed of it. It may, therefore, be considered as a general formation over the basin of Lake Superior. It rises to about the height of 400 feet above the lake, and rests on granite on either shore, excepting where amygdaloids or other traps may have been intruded between. It has been only occasionally upheaved by the granite; but it is often much shattered by the trap-rocks, nodules of which enter largely into the composition of its conglomerates. It is often extensively overlaid, especially in Mepigon Bay, by immense beds of greenstone several

hundred feet thick, and sometimes also by amygdaloid, with which it is occasionally, although rarely, interstratified. Large rounded fragments of the trap rocks of the lake, especially the porphyries, occur abundantly in its conglomerates, and sometimes form entire beds near the parent rock. Hence we perceive that volcanic energy was active, or at least had not ceased, during the period of its deposition.

In general, however, this sandstone is composed of fine grains of quartz and felspar, together with rounded particles of primitive and trap rocks; and it is important to remark, that no fragment of the Silurian fossiliferous limestones, known to occur to the northward towards Hudson's Bay and extensively on Lake Huron, was ever noticed in its conglomerates.

Grains of mica are sometimes abundant, especially near its contact with granite. It is sometimes calcareous, the carbonate of lime occurring also in veins. It is often ferruginous, and there are sometimes between its strata thin layers of a black sandstone, which crumbles easily into a black, heavy, and highly magnetic sand, very plentiful on the beaches, and which Mr. Tennant informs me is the titaniferous oxide of iron. On the islands called "the Twelve Apostles," on the south coast, there are beds of ferruginous red marl. In colour this sandstone is often variegated — being red, white, grey, yellow, and dark reddish-brown. The only metallic minerals found in it are iron and copper ores.*

No organic remains having as yet been found in this sandstone, and its junction with the Lake Huron limestone in the river St. Mary's below the rapids being hidden by drift, water, or an almost impervious forest, so as hitherto to have escaped notice, it is difficult to determine with any confidence its place or age. There seems no reason to think that it can be more recent than the old red sandstone; and when it is considered that it appears in the St. Mary's at low levels, forming nearly horizontal strata at the bottom of Lake George, whilst the horizontal fossiliferous limestone of Sugar Island and St. Joseph's rises into higher ridges, so as to make it appear *highly probable* that the sandstone occupies the inferior position; and that, moreover, a sandstone is known very generally to underlie transition limestone in Canada and the United States: when all this is taken into account it is, perhaps, not unlikely that the sandstone in question may belong to the Silurian rather than the Devonian period. On the other hand, its appearance in unworn slabs, that must be near their parent rock in the neighbourhood of Michilimackinac, where great beds of gypsum occur, would seem unfavourable to this conclusion; as may also, perhaps, the red marly beds of the Twelve Apostles.

This sandstone, although not observed in the river St. Mary below

* The principal locality of the copper is about seven miles westward of the eastern extremity of Port Keewawonan, where there is a vein of malachite, with brown and earthy-blue copper, five or six feet wide. This occurs in conglomerate; but the same minerals are found in trap-rocks near the same places.

Lake George, is succeeded to the eastward by the fossiliferous limestone of Lake Huron, which rests in like manner on the primary rocks of the north coast, excepting for a few leagues at La Cloche, where quartz-rock is interspersed between it and the older rocks. This quartz-rock forms a range of hills, which are considered to rise at least 1000 feet above the lake, and can be seen towering over the Manitoulins from a distance of many leagues. It also forms some of the islands between the Great Manitoulin and the main land, where the limestone may be seen overlying it in nearly horizontal strata. Although in some parts highly crystalline, in others it is arenaceous, and passes into a conglomerate of great beauty, being studded with nodules, both rounded and angular, of various coloured jaspers, quartz, calcedony, carnelian, &c. This rock occurs in immense cubical blocks; its stratification is obscure; and its prevailing direction to the N.E.

Dr. Bigsby, in a paper read before the Geological Society in 1823*, has given a description of the rocks and minerals of Lake Huron. A recapitulation is here unnecessary. I shall merely observe, that the primary beds and accompanying traps do not occur on the same scale of grandeur as on the shores of Lake Superior; they are less elevated, more shattered, and less uniform in direction, although the predominating strike is still to the N.E. An obscure dip to the S.E., at a high angle, is discoverable occasionally, but only when the structure of the rock is gneissose, which is more often the case than on Lake Superior. The granitic compounds very frequently contain hornblende.

But the limestone of Lake Huron, like the sandstone of Lake Superior, is a general formation over the whole lake. It is found, as already observed, reposing on primary rocks at many points along the northern shore from one extremity of the lake to the other. It forms the large island of St. Joseph's, and the point of land that separates the river St. Mary from the strait of Michilimackinac; the S.W. coast as far to the south as Sagana Bay; the entire range of the Manitoulin Islands; the great promontory of Cabot's Head; and the eastern coast fifty or sixty miles to the southward and eastward of it; and it probably extends much further in that direction beneath the beds of sand and clay so prevalent in western Canada. In Dr. Bigsby's paper already referred to, and in a paper read before the Society in 1837, will be found an interesting description by Mr. C. Stokes of some of the most characteristic fossils of this limestone, especially of the *Orthoceratites*, and the museum of the Geological Society contains many specimens from various localities. These, although probably far from comprising a complete series, seem nevertheless sufficient to enable us to assign to this limestone its analogous place among European strata. Among those fossils we may point to the *Spirifer lynx*(?) and *Pentamerus oblongus*, as indicating a considerable ascending range in the Silurian system of Mr. Murchison; and the numerous corals which were mostly found in the upper

* Geol. Tr. 2d Ser. vol. i. p. 175.

beds of Drummond Island and the other Manitoulines, would lead us to the same probable conclusion.

And this is what we ought to expect when we consider that this limestone, although termed horizontal, is not strictly so. In the comparatively small space which the eye can take in at a near view it appears so; but when we view the islands with their cliffs as a whole, from a distance, or observe the gradual ascent of the limestone plains as we proceed inland over the barrens on the south side of the Great Manitoulin, and their gradual descent under the waters of the lake in the contrary direction, we perceive that there is a dip to the southward of some feet in a mile, which, continued for 100 miles or more, must give a very considerable thickness of strata.

From the eastern extremity of Lake Huron, and still advancing eastwards, we trace the Silurian limestone with similar fossils, across to Lake Simcoe, to the Rice Lakes, and, on the north of Ontario, to Kingston and the Thousand Islands*, and thence again, north-eastward by Perth, Bytown, and Lake Chât, across the Ottawa River† to Montreal and Quebec. It may also be seen at various intermediate points along the northern side of the valley of the St. Lawrence. At Port aux Trembles for instance, about six leagues above Quebec, we find it containing, among other fossils, *Calymene Blumenbachii*, and a species of *Chonetes*, which M. de Verneuil informs me is allied to *C. petropolitanus*. The limestone here dips to the S. E. conformably to the grauwacké, which contains *Leptæna sericea*, on the opposite or southern shores of the river. This latter circumstance, together with the statements of an anonymous writer in the Canadian Review‡, that the limestone near the falls of Montmorenci declines gradually from the horizontal position till it finally dips at a high angle beneath the grauwacké; and that a conglomerate, wholly composed of re-cemented fragments of limestone containing the organic remains peculiar to Beauport, the falls of St. Charles, and Indian Lorette, is one of the alternating members of the grauwacké and slate series, incline us to assign to this limestone a position inferior to the grauwacké and slate, and low down among the Silurian strata. This view is strengthened by the occurrence of a similar limestone on Lake St. John underlying clay slate, and containing *Isotelus gigas* and an *Ormoceras*, like those of Lake Huron, &c. Considerable difficulty, however, has been felt in admitting this, because the limestone has so very generally been found in nearly horizontal strata, resting immediately on primitive rocks in very near neighbourhood to the highly

* Here, and also near Kingston, masses of sulphate of strontia and calc-spar, with disseminated iron pyrites and sulphate of zinc, are found in the limestone.

† On the Ottawa, above Lake Chât, and also on the St. Lawrence, near Gananôqui, primary white granular limestone occurs extensively, associated with green serpentine, steatite, compact and fibrous asbestos, and occasionally containing, as I am informed by Mr. Tennant, brucite, tremolite, plumbago, and mica.

‡ In an article in the second number attributed to Dr. Bigsby, and published some years ago.

inclined grauwacké and slate ; but, on the other hand, it must be remarked that it has never, as far as we know, been found overlying the latter unconformably, although sandstone or conglomerate is occasionally interposed between it and the granite or gneiss, as among the Thousand Islands, and on the rivers St. Maurice and Montmorenci.

The northern shore of the St. Lawrence River and Gulf, from Cape Tourment, ten leagues below Quebec, eastward to the Mingan Islands, is composed of primary rocks ; the limestone and the grauwacké which form the islands and southern shore of the river, appearing in immediate contact with them only at St. Paul's and Murray Bays, and, more extensively, on Lake St. John, up the Saguenay River, as already mentioned.

For a more particular description of the primary rocks of this coast, and also of the Mingan Islands, with their raised beaches, limestone columns, &c., I must refer to a paper read before the Geological Society in 1833, and printed in their Transactions*, which was accompanied by specimens of the fossils which I have now added to, and which have been examined by M. de Verneuil, to whom I am indebted for their specific names, and many valuable remarks respecting them. On this occasion it will be sufficient to state, that the Mingan Islands extend for about fifty miles along the north coast of the Gulf of St. Lawrence, opposite the great Island of Anticosti, from which, at the nearest point, they are distant about nine miles. None of them are more than three miles distant from the main land, where the limestone may be seen at various points resting immediately on granitic rocks.

The Mingan Islands are entirely composed of limestone, having a slight dip to the southward. So also is the Island of Anticosti, which, from its relative position to the southward, and similar dip, may be expected to be higher up in the Silurian series. The limestone of these islands resembles that of Lake Huron, in being very nearly horizontal ; although there is a slight dip, which, continued for many miles, must give a very considerable thickness to the whole range, measuring from the lower beds that rest on the granite of the mainland to those that dip gradually beneath the sea on the southern coast of Anticosti, or form the summits of the unvisited ridges of the interior of the island, five or six hundred feet above the sea.

The following are the most abundant fossils of the islands of Mingan : —

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| 1. <i>Illænus crassicauda</i> . | 5. <i>Terebrátula plicatella</i> (not Sow.). |
| 2. <i>Orthoceras duplex</i> . | 6. <i>Euermis</i> ? |
| 3. <i>Orthoceras annulatus</i> . | 7. <i>Leptæna Humboldtii</i> . |
| 4. <i>Euomphalus</i> . | 8. <i>Pleurotomaria</i> . |

And of the Island of Anticosti : —

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| 1. <i>Spirifer lynx</i> (Eichwald), var. | 2. <i>Orthis</i> , allied to <i>O. elegantula</i> . |
| of <i>S. biforatus</i> (Schlotheim). | 3. <i>Leptæna Humboldtii</i> (De Vern.). |

* Geol. Tr. 2d Ser. vol. v. p. 89.

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|-----------------------------------|---|
| 4. <i>Leptæna sericea</i> . | 7. <i>Atrypa reticularis</i> ; (syn. |
| 5. <i>Orthoceras</i> . | <i>A. affinis</i> & <i>A. prisca</i>). |
| 6. <i>Favosites gothlandica</i> . | 8. <i>Turbo</i> . |
| | 9. <i>Pentamerus oblongus</i> . |

These, although doubtless far from comprising all that may be found, will be sufficient to establish the Silurian character of the limestone of these islands, and to show the general resemblance of the fauna to that which is indicated by the organic remains of similar formations occupying an analogous position in Europe.

From the Mingan Islands to the Strait of Belle Isle, the coast of Labrador consists exclusively of primary rocks, but on the east side of Bras d'or Harbour we meet with transition sandstone, which at one point appears to pass distinctly into gneiss. The sandstone extends about thirty miles along the northern side of the Strait of Belle Isle, from Bras d'or to the eastward, and forms table-lands 400 or 500 feet high, with cliffs towards the sea, and terraces ascending one within the other to considerable distances inland. These seem due to aqueous denudation, and, like the inland cliffs and flower-pot columns of the Mingan Islands, may mark, although less distinctly, successive periods during the emergence of the sandstone from the sea. This sandstone occurs in nearly horizontal strata, dipping, if at all, very slightly to the southward, and resting on granite. On the eastern point of Fortean Bay, a red and white limestone* underlies the sandstone, and contains *Cyathophyllum*; which fact, together with its position, immediately reposing on granite, affords the only data from which to infer the relative age of this formation.

The opposite, or Newfoundland side of the strait is of limestone; containing, at Cape Norman, *Orthoceras duplex*, *Orthoceras* allied to *O. annulatus*, *Euomphalus affinis*, *E. gualterius*, and *Clymenia*? or *Lituities*. I observed this limestone, which is in nearly horizontal strata, as far to the southward along the west coast of Newfoundland as Port Saunders, and it probably extends still further in that direction. It is then succeeded by sandstones, and perhaps by other rocks in ascending order to the coal, which is reported to occur in St. George's Bay.

At Chatian Bay, and also at Table Point, opposite Belle Isle, we met with columnar basalt† capping granitic hills, at an elevation of about 200 feet above the sea. The basalt is in vertical prisms 25 or 30 feet high, having from five to eight sides. It is black, ferruginous, magnetic, and contains crystals of olivine. It rests, at Table Point, upon a conglomerate of rounded pebbles of quartz and felspar, with oxide of iron and silvery mica, the whole so changed by the contact that, in some hand specimens, we might almost take it for granite. It has also acquired an irregularly prismatic structure, large columnar masses of it breaking away

* It is worthy of remark that a somewhat similar limestone, but destitute of organic remains, was observed by Dr. Bigsby underlying and alternating with sandstone at Thunder Cape on Lake Superior.

† Literary and Historical Society of Quebec, vol. i. p. 71.

from the cliff from the effect of the severe frosts of winter. It occurs in a horizontal bed or stratum, about ten feet thick, forming, together with the incumbent basalt, a tabular oval mass, about three quarters of a mile in diameter, with cliffs 40 or 50 feet high, resting on granite. Both its irregularly prismatic and partially crystalline structure seem due to the effect of the basalt which has flowed over it. There is also an altered sedimentary rock under the basalt of Chatian Bay, where the change from sandstone into a ferruginous shale has been nearly completed.

These isolated patches of basalt and conglomerate, capping granitic hills at the same elevation, and at the distance of fifteen miles apart, appear to be the denuded remains of an extensive formation.

In the mica schist which occurs on the north side of Henley Island, near the basalt just mentioned, there occurs a large vein, containing a beautiful aggregate of green and white felspar, with quartz, oxide of iron, mica, and garnets. Chlorite, with specular iron and hornblende, occurs in the same locality.

It would swell this paper to an inconvenient length to enter into a particular description of the primary and trap rocks of the region, or the minerals which they contain; but we may mention briefly that mica-schist prevails most near St. Paul's Bay, where it abounds with garnets, and where chlorophane was found. Further eastward hornblende and felspar predominate, forming, with or without quartz and mica, various compounds. Between the Seven Islands and Mingan, bronzite or hypersthene, hornblende, felspar, and the magnetic black oxide of iron, form a rock which occupies many miles of coast.* Shorl, epidote, garnets, and micaceous iron were noticed in the various granitic compounds which occur on this long line of coast.

Having thus, very generally, traced the line of junction, doubtless once continuous, of the transition strata with the primary rocks, from the head of Lake Superior to the Strait of Belle Isle, and having pointed out the occurrence of Silurian limestone at the northern extremity of Newfoundland, and shown that the intervening rocks up to the coal may probably be found along the western coast of that island, I shall conclude with some brief and very general remarks on the ascending succession of the rocks of eastern Canada, as exhibited along the shores of the district of Gaspé.

At Cape Rozier the grauwacké and slate rocks which were observed forming the southern shore of the St. Lawrence below Quebec, at every point where we had an opportunity of landing, are succeeded by the Cape Gaspé limestone, forming cliffs 900 feet high, and dipping conformably at an angle of about 25 degrees to the S. S. W. It contains *Orthoceratites*, *Producta*, *Encrinites*, and corals, of which I regret that the specimens have been lost. Thin veins of galena and blende also occur in it, but are not worth the working.

* The felspars are often striated, and sometimes opalescent.

This limestone is succeeded in ascending order by a series of shales and sandstones all highly carboniferous. The sandstone on the north side of Gaspé Basin is calcareous, and contains, according to Mr. De Verneuil, *Orthis*, *Leptæna* (*Chonetes*) *sarcinulata*, approaching to the Eifel species; *Terebratula*, a large variety, and two other smaller species; and *Chonetes affinis* (*C. papilionacea* of the coal measures), described by Phillips as a *Spirifer* (*S. papilionacea*).

The shales and sandstones are much disturbed, but nevertheless preserve a general dip to the southward. Proceeding in that direction across Mal Bay, we find a variegated reddish, yellowish, and white crystalline limestone, with concentric concretions, and without organic remains, supporting conglomerate and red sandstones; the latter forming the summit of Percé Mountain, 1300 feet above the sea. The general dip is here also to the southward, or S.W. Organic remains are reported to have been found in the adjacent Percé rock, but I have not seen them.

Bonaventure Island is of conglomerate nearly horizontal. As we proceed up the Bay of Chaleur we may notice the red sandstone forming cliffs in nearly horizontal strata in the bays, whilst the points are in general formed of harder rocks. These are sometimes trap-rocks; at others, hard conglomerate, whose nodules seem glazed, as if they had been dipped in the siliceous and calcareous fluid, which in cooling had formed the cementing agent in the formation of the rock. I also noticed reddish and greyish limestone abounding with the stems of *Enerinites*; but other fossils appeared very rare; and I only found a *Terebratula* allied to *T. ferita*. These limestones occur principally at Port Daniel, and, together with the associated conglomerates and sandstones, are very much disturbed; but the red sandstone is less so than the rest, and is doubtless the uppermost of the series. We have now arrived near the southern extremity of the district of Gaspé, and I have communicated all the scanty information as yet possessed respecting this interesting part of the country, where the rocks that intervene between the Silurian strata and the coal may perhaps be best studied. The limestone of Cape Gaspé has hitherto been considered analogous to the mountain limestone; but the fossils of the calcareous sandstone of Gaspé Basin which I have enumerated, and which Mr. Lyell, I believe, considers Devonian, will render it necessary to reconsider this subject. The highly carboniferous sandstones and shales that succeed to the southward, the occurrence of petroleum springs, and of an impure coal in small quantities near Percé and at Port Daniel, assist us in referring the rocks of this part of the country to the carboniferous period, thus indicating our approach to the coal measures of New Brunswick, on the opposite side of the bay where coal fossils are found.

April 16. 1845.

On the supposed Evidences of the former Existence of Glaciers in NORTH WALES. By ANGUS FRIEND MACINTOSH, Esq., F.G.S.

THE author states, that having noticed some remarkable phenomena in a part of North Wales, which seemed to militate strongly against the theory advanced by Prof. Agassiz, and supported by Dr. Buckland, on the subject of glaciers, he was induced to examine carefully the district in question, and that, after long investigation, he has formed a decided opinion that the district affords no sufficient proof of the former existence of glaciers in any part of it. He then considers *seriatim* the different points of evidence that have been adduced and their value.

1. *Rounded Surfaces of Rock.*—These appearances, which have been referred to by Dr. Buckland as having been caused by glacial action, abound in several of the Welsh valleys, in some instances (near Bedd-gelert and the pass of Llanberis) at the height of 800 and 1000 feet, and in others at a very much more considerable elevation. If, however, it was by the agency of ice that such rounded surfaces were produced, the valley must have been entirely occupied by the glacier, which in some cases it would seem must have had a thickness of at least 2500 feet. This indeed is according to M. Agassiz' theory, that the ice extended downwards to the plains, and covered the surface; but the modified form of it adopted by Dr. Buckland does not in the author's view account for the existence of the rounded masses, since they are promiscuously dispersed in some of the valleys, occurring in numerous and very different directions, and often where no true glacier could be supposed to have reached them.

The want of height in the Snowdonian hills is adduced by the author as an argument that such vast bodies of snow and ice could not have been formed on them, since the length of glaciers is known to be in the ratio of the height of the mountain whence they proceed; and he further observes that the glacial theory with regard to these rounded surfaces is also strongly opposed by appearances which occur on both sides of the lower Llanberis lake on the old Bangor road, near the south end of the Penrhyn quarries in the valley of Nant Francon at its upper extremity, and in several other places. Here the rounded surfaces are seen immediately in contact with, and directly under cover of, other masses higher than themselves, these latter standing immediately before them in the line of descent, and yet having their edges, over which the glacier must have passed (if it rounded the rocks below), angular, and

occasionally even sharp. Other rounded surfaces are met with in the deep sharp angles of rock, and in recesses where it is not to be conceived that a glacier could have forced its way, and produced this effect, leaving the inner sides of these recesses unworn by friction and their edges angular. In some of these cases the rounding of the narrow parts is perfect, and they are occasionally even fluted in a manner identical with that of other flutings in the exposed and open parts of the rock.

The author then refers to another example of rounded, grooved, and striated rocks seen in the valley of the Ogwyn near the bridge, where the river as it issues from the lake forms a cascade at a spot close to the high road. The rounded rocks here are described as weathered; but "quartz veins which traverse the masses, and project two inches above the surface, are polished and rounded on the edges;" and in this group of rounded, dome-shaped bosses, some of the surfaces are fluted, the furrows being regularly parallel and equidistant, and as nearly as possible of the same width and depth.

At first sight the appearance here presented seems to be referable to glacial action; but the author observed that the direction of the flutings is opposed to that of the valley; that the striæ or furrows which are not parallel are likewise not in the direction of the line of the valley, but range at all points of the compass, many of them crossing one another irregularly, and others having a radiated appearance, and that in the midst of the parallel furrows on the rounded smooth faces of rock are projecting portions of the same rock, some of them rounded, fluted, and striated at the tops, but angular at the edges, and not rubbed at the sides, while smaller portions, scarcely an inch thick, stand fully exposed in the line of descent which a glacier must have taken, presenting the appearance of thin portions of schist full two feet in height, and almost as much in breadth, perfectly unaltered. Although the rounding of the general surface has taken place on each side of them, the flutings are in absolute contact with them, and there are striæ between and even upon them. It seems clear, that had the rounding of the rock been effected by the passage of a glacier, these fragments must necessarily have been swept away, and thus the rounding of the rocks must be due to some other process.

It is the opinion of the author that this rounding took place beneath the sea, and that the repeated undulations of the strata parallel to the principal mountain chain in the district, forming a succession of anticlinal and synclinal axes, have been the original cause of the formation of the oblong bosses and rounded rocks, while the fracture of the beds has produced the furrowed appearance. It is also suggested as explanatory of this view that, at the time of the disturbances which produced these undulations, the rocks may have been only partly consolidated, and that thus the long parallel lines at first produced might readily be acted on by the marine currents, which were sufficiently powerful to clear off the sharp edges, but not to remove the projecting quartz veins.

The author concludes this part of his memoir by stating his

belief that even where this view of the origin of the bosses does not apply, he believes that sub-marine, and not glacial, action must be referred to, since many of the rounded rocks possess features which render it extremely unlikely that they could have been rounded by glaciers, while others are so circumstanced that it would seem to have been absolutely impossible.

2. *Fluted and striated Surfaces.* — Having shown that the rounding of rocks was in all probability not effected by glacial action in North Wales, the author proceeds to show that the fluted and striated appearances, also referred to the passage of large bodies of ice, are really due to other causes; and he first considers an example referred to by Dr. Buckland, and situated about 100 yards below the bridge of Pont-aber-Glasslyn, near Bedd-Gelert, on the right bank of the river.

At this spot the rocks are rounded and polished, and covered by flutings and striæ generally parallel to the course of the valley; but the author observes that such is not always the case, some of the striæ being very oblique, and some actually opposed to this direction.

The flutings in the instance now under consideration are also considered to be more regular, more accurately parallel, and more symmetrically placed than could be the case had they been produced by the passage of a glacier. These flutings in the Snowdonian schists rarely vary in any perceptible degree on the same surface; there is little or no distinguishable difference in their depths or breadths; and however numerous the lines, they are uniformly and strictly parallel. They are also at equal distances from each other, and are so similar in different valleys that the resemblance is striking. Phenomena of such a kind must, it is concluded, be *structural*; and the author believes that not only do the furrows but also the striæ — which are not parallel, but more or less oblique and irregular — owe their existence to the internal structure of the rocks.

The flutings and striæ of the rocks in the valley of the Llugwy between Pont-y-Gyffing and Capel Curig, described by Dr. Buckland, are next alluded to. In this case the fluted lines on some of the rocks on the Bangor or western side of the large dome-shaped masses mentioned by Dr. Buckland, are stated to be in actual opposition to the direction of the valley, although such flutings agree in all their characters with others in the direction of the valley, being parallel to one another, equi-distant, and as nearly as possible of the same width and depth. That these flutings are natural furrows, and not due to glacial action, the following facts are then adduced by the author as sufficient proofs.

In the first place it is stated that close to the large dome-shaped masses at about 200 yards from their western base, nearly opposite the road which leads to Capel Curig, there are certain low rounded rocks or bosses marked with furrows at right angles to one another, and that the same occurs on a small mass of schist about midway on the north side of the lower Llanberis Lake. These rocks also

are regularly furrowed in continuous parallel lines, not only from top to bottom, but on each of the sides accessible to view. The furrows must, therefore, be structural phenomena.

Secondly, that the parallel markings on the conglomerates opposite Capel Curig to the north are broader, deeper, and wider apart than those of the schists which they overlie, agreeing apparently with their wider and larger lines of bedding.

Thirdly, that in these conglomerates are contained fragments of the schist, some of them about half a foot square, marked with regular parallel flutings at equal distances, exactly in the same manner as the rocks *in situ*. These marks are by no means in the direction of the valley, but indifferently in every direction according to the position of the fragment in the conglomerate; and the matrix in which they are contained is entirely free from such markings, while the furrows are not merely to be traced on the exposed parts, but are continued within the substance of the conglomerate, the lower or buried sides being fluted in the same manner as the upper portion.

Hence it appears from the condition of these bedded fragments, first, that glacial action could not have produced the flutings and furrows observed upon them, since the direction of the furrows is not that of the valley; next, that such glacial action could not have been the cause of the rounding of the rocks, since, in that case, the fragments in question would have been carried away, instead of left standing, as they are, half an inch above the surface; thirdly, that the rounding in question must have taken place after the consolidation of the schists, but while the conglomerates were still comparatively soft; fourthly, that the furrows were produced before the formation of the conglomerates, and were for that reason independent of any glacial action, and, in all probability, structural; and, lastly, that the furrowing and the rounding of these rocks are entirely distinct and independent phenomena, due to very different causes.

Another example of furrowed rocks is seen on the right bank of the lower Llanberis Lake, close to the quarry railway, and rather more than midway from the upper end of the lake, where a low oblong rock, consisting of a coarse bluish slate, passes somewhat abruptly into a conglomerate. This rock is rounded and fluted, but the flutings cease exactly where the conglomerate begins.

The *striae* or markings not parallel to one another observed on many rocks, and referred by some to glacial action, are likewise considered by the author to be structural phenomena, since they occur in situations where the passage of a glacier could hardly have produced them, as in narrow recesses of rock, the edges of which are angular, and on the projecting fragments of beds, the rest of which have been denuded. These *striae* are generally narrow and shallow lines, seldom more than a quarter of an inch in breadth but usually less, and some of the thinner ones, having the

appearance of straight scratches, seem to be parts of weathered cleavage lines, appearing interruptedly here and there.

The author believes that other striæ, more or less oblique and irregular, and occasionally intersecting the former, have arisen from cracks. The markings of this kind are rarely if ever curved, differing in this respect from the glacial striæ described by M. Agassiz, while they are often bent at an angle, and occasionally in such a manner that it is difficult to understand how a descending body could have produced them. They also, many of them, have flat surfaces, unlike the scorings produced by the pressure of angular fragments. That such striæ, or at least a large number of them, were originally mere open splits or cracks, to which exposure has given their present appearance, is suggested by the author as probable, since, in many instances, they bear an almost exact resemblance in width, length, angular character, and general form to certain open cracks appearing on the surface of schists which have been only a few years exposed, and of which examples may be seen in the Penrhyn quarries on the south side, and again, very strikingly, close to the Ogwyn Lake.

Referring once more to the furrows or flutings before described, the author next states that, according to his observation, these markings are always parallel to the cleavage, and correspond to one of the sets or series of narrow lines or joints, called by the quarry-men "Water-splits," which are also parallel to the cleavage, and are about half an inch apart. These water-splits are in some cases quite open, in others they are seen partially filled up, and in others, again, the process is farther advanced, and the furrowed or fluted appearance is distinct. There is also a striking agreement in the general width of these open lines with those of the flutings, so that, on the whole, he concludes that the water-splits or what he denominates "open cleavage joints," have been the origin of the parallel flutings*; and open cracks that of most of the striæ. He also states that the existence of scratches, properly called "structural," can be distinctly proved on a small scale, since even the weathered coatings of the schists, thin as they sometimes are, have their own peculiar striæ; and although it requires the aid of a magnifying glass to see them, they then show clearly as minute delicate lines of an inch or two in length, very numerous, more or less straight, and often intersecting one another. They are, however, resemblances in miniature of certain apparent scratches belonging to the rocks.

The author then adverts to similar phenomena of striated and furrowed rocks, described as occurring in America, and which have been explained by Prof. Hitchcock on the glacial hypothesis, but which neither that hypothesis nor the passage of ice-floes over the surface are sufficient to explain satisfactorily. The view advocated above, of the structural nature of such markings in the

* Examples of open parallel lines occur on the right bank of the lower Llanberis Lake, and in the large adjoining quarries of Mr. Assheton Smith.

Welsh slates, is also suggested as the probable explanation of similar appearances elsewhere.

3. *Polished Rocks.*—The surface of rocks of various kinds and at very different elevations, has frequently been observed to exhibit a polish, which has usually been attributed of late to the action of ice. The author considers that some of these cases are doubtful; that the polish is not of long endurance when the surface is exposed; and that in some, at least, of the examples in North Wales, the polish has been produced by the sliding of boys on the smooth rock. This latter explanation he considers as sufficient in the case mentioned by Dr. Buckland at Bedd-Gelert, near Pont-aber-Glasslyn, where a portion of surface, measuring about 15 feet by 2 feet, is obviously polished, but where the rock is weathered, and does not exhibit the appearance except at this spot. Another example at Bedd-Gelert, at the north-east of the village near the turnpike, also quoted by Dr. Buckland, is considered by the author insufficient to support the glacial theory; since, although in this case the rock is intersected by numerous quartz veins which project about two inches above the surface, but preserve their polished and rounded outline, other similar appearances, which could not have been produced by ice, occur also in rounded rocks, as, for instance, in narrow recesses having angular edges which no glacier could have touched. The author considers that, as such apparent polish is not seen in the great majority of cases, it may be due to varying mineral conditions*; but he expresses his conviction that, as the surface apparently polished has, in every case that he examined, been manifestly a weathered surface, it cannot possibly have been produced by glacial action, since the actual surface would in that case be exhibited, and not the weathered coating, which is necessarily of much newer date. At any rate, whether, as he believes, the polishing of rocks is *in no case* attributable to ice, in any shape, but always to some other mechanical causes, or to atmospheric exposure; or whatever the cause may be, the polish cannot have been retained unaltered during so long a period; and even if it could, since this appearance belongs, not to a freshly exposed surface, but to a surface covered by a film of decomposed rock, it certainly was not that over which the ice passed.

4. *Moraines.*—The instances adduced by Dr. Buckland in North Wales as referable to this class of glacial phenomena are considered by the author as unsatisfactory; and he refers, first, to the elevated plain of Pentre-Voelas, said to present large accumulations of unstratified detritus having the aspect of moraines, but supposed to have been afterwards modified by the action of water. It is objected, that in this detritus there are no true rounded and striated blocks nor rounded pebbles, neither are there mixtures of different fragments of all forms and sizes, such as usually belong

* The author here observes, as an additional argument against the probability of glaciers having formerly existed where this so-called polished rock appears, that the rock abounds with concretions standing in relief above its general surface.

to moraines. It is also observed that the physical structure of the country round Pentre-Voelas is that of an open and widely extended plain, — Snowdon being twenty miles off, and there being no height of any consequence much nearer; so that it is impossible to conjecture whence such enormous masses of ice could be derived, or how they could have been urged forwards to distribute the detritus.

The next instance alluded to is between Pont-y-Gyffing and Capel Curig, and consists of a mound of gravel close above certain dome-shaped hummocks, in front of the confluence of the upper valley of the Llugwy with that of Nant-y-Gwyrdd. In this case, however, the author discovered, on examination, that what appears to be a mound of gravel is merely a low wavy ridge of schist, whose ragged and weathered surfaces seem, at a little distance, as if covered with fragments; although, in fact, they are nearly bare. The author therefore believes that no such gravel exists on the spot alluded to.

Another of the supposed moraines referred to by Dr. Buckland occurs near the elevated lake of the Flynnon Llugwy, north of the road leading from Capel Curig to Bethesda. It consists of two principal streams of blocks, one extending downwards in a S.W. direction from near the lower end of the lake for about two miles and a half; the other taking an opposite course, and reaching partly across the upper end of the valley, a distance of nearly half a mile. The former of these groups is marked by no glacial feature, and is chiefly remarkable for its length and its general conformity to the curves of the river; but the latter or smaller group exhibits at its further extremity four or five detached piles of angular blocks about twenty feet in height. Near its point of commencement also, on the west side of the valley, it passes over two mounds, 20 or 30 feet high, covered with peat and herbage; and a similar mound, somewhat larger and higher, occurs at the other end of the line, having also blocks upon its top.

The author considers that the blocks forming this group have descended from the mountain on the western side of the valley, but that, since there are no rounded blocks and flat-sided pebbles, such as are seen in Alpine glaciers, and indeed no traces of glacial action, the deposit must have found its way from the mountain, traversing a distance of nearly half a mile, and that some of the blocks, after crossing the little stream of the Llugwy, have ascended for perhaps 20 or 30 feet above it. This transit, it is considered, may have been effected by the aid of snow and ice, though not in the form of a glacier; and in support of this view, two occurrences are described bearing upon the point. One of these took place in the winter of 1813-14, when drifted snow had so accumulated in the course of several weeks near the mountain stream called the Affon Bertham, in the valley of Nant Francon, that it formed a deep broad sloping talus, above a quarter of a mile in length, so compact that men and horses and fully-laden carts frequently passed over it; and the other, in the same valley,

only five or six winters ago, at a spot called Cefn-y-Orsidd, where the slope of the mountain ridge is about 15° or 20° , and where numerous blocks frozen together became suddenly disengaged by a thaw, and moving downwards on sheets or sledges of ice, they travelled over a space of nearly 400 yards, and were there checked by the resistance of a wall, part of which, however, was broken through and removed. From these instances, occurring in our own country at a moderate elevation, it will be seen to be possible that boulders, even of considerable size, may be removed without glacial action.

With regard to the Flynnon Llugwy boulders, therefore, as there appears no evidence of their being due to glacial action, their presence may be better accounted for in some such manner as this. The author concludes by observing concerning them, that they do not, as Dr. Buckland considers, repose on small gravel, except near the river, and where this gravel has been subsequently washed under them.

APRIL 30th, 1845.

On the PALÆOZOIC DEPOSITS of SCANDINAVIA and the BALTIC PROVINCES of RUSSIA, and their relations to Azoic or more ancient crystalline Rocks; with an account of some great features of dislocation and metamorphism along their northern frontiers. By RODERICK IMPEY MURCHISON, V. P. R. S., V. P. G. S., Pres. Roy. Geog. Soc., and Cor. Mem. Inst. Fr.

THE views of my friends, M. de Verneuil, Count Keyserling, and myself respecting the geological structure of large portions of Russia, particularly in reference to the palæozoic succession of that country, have been already laid before the Society. In those communications allusions were made to the absence of a well-defined base line for the Silurian rocks of the Baltic and the eastern governments of the empire, owing in some instances to the interposition of arms of the sea, or great interior lakes; in others, to great masses of detritus, which occupy the surface along the boundary line; and in others again to the prevalence of eruptive rocks, which have to a great extent metamorphosed the sedimentary masses conterminous with the crystalline rocks of Lapland.

To remedy, if possible, what would have been serious defects in a work on the structure of Russia which is about to be published, and to satisfy myself as to whether the great masses of crystalline rocks which range from Scandinavia over Finland and Lapland, were truly more ancient than any thing to which the term "Silurian" could be applied, or were simply metamorphosed portions of the Silurian system, as some geologists had supposed, I last year visited Norway, Sweden, and Finland, and again revisited St. Petersburg. Having now adopted definite views on this subject, having also completely satisfied myself respecting those tracts which are referable respectively to lower and upper Silurian rocks, and having observed a copious development of old

red sandstone in Norway, as well as a very remarkable junction between its Devonian equivalent and the lower Silurian rocks of the government of St. Petersburg, I now lay the result before the Society, communicating both those general views which will appear in the forthcoming work on Russia, and also some details respecting Norway and Sweden which do not appear therein. The remarks which I now make on Scandinavia are, however, to be simply considered as the first of a series of communications which I hope to be able to continue by subsequent surveys of that region, in which I have the promise of being joined by M. de Verneuil.

The present memoir is therefore to be regarded as an outline sketch only of certain broad lines of demarcation to which it is essential that geologists should attend when investigating similar phenomena which have not yet been sufficiently worked out.

It will readily be understood when a few of the more prominent facts of the case are laid before the reader, that in order to give a history of the whole series of sedimentary deposits of Russia, we must commence with a sketch of the adjacent Scandinavian regions, which, chiefly occupied by highly crystalline rocks, are in many places covered with patches of ancient strata containing organic remains.

The fossils, indeed, described by several writers, had shown that true Silurian deposits existed in Sweden and Norway, and it was therefore necessary for us to see and describe the absolute contact of the lowest sedimentary strata with the crystalline rocks of that region. We have come to the conclusion that the lowest of these beds that are fossiliferous are the exact equivalents of the lower Silurian strata of the British Isles, and that they have been formed out of and rest upon slaty and other rocks which had undergone crystallisation before their particles were ground up to compose the earliest beds in which remains of organic life appear. We apply to these crystalline masses, therefore, the term *Azoic*, simply to express that, while as far as research has hitherto gone no vestiges of living things have been found in them, so also from their nature they seem to have been formed under such accompanying conditions of intense heat and fusion, that it is hopeless to attempt to find in them traces of organisation.

The great extent of the crystalline rocks in Scandinavia is one of the features which first strikes the ordinary observer with surprise. They occupy the great bulk of Sweden, and are at present undergoing very careful examination and minute description by several able mineralogists in Norway. They rise into mountains, and form the flanks of troughs containing palæozoic strata, which have in their turn been invaded by granitic, porphyritic, and trappean rocks of another epoch. Although extremely broken up and diversified by various plutonic rocks, and very much dislocated, the lower members of these ancient strata consist of quartzose sandstone and hard slaty schists, the former visible in some tracts only, as at Vigersund on the Drammen, the latter being the well-known fucoid alum-shale of the country, and forming the

prevalent base in the Christiania fjord. These lowest strata are surmounted by black limestones and shale, charged with fossils, which leave no doubt that the inferior group represents the lower Silurian rocks of the British Isles.*

As a whole these lower Silurian rocks of Norway have very little of the arenaceous character which the same group assumes in certain tracts of Britain, but are most analogous to the schists and calcareous flags of Llandeilo, where those masses have not assumed a slaty structure. This lower division is overlaid by shales and massive coralline limestones, containing many of the typical species of the Wenlock limestone in the British Isles, and these again by calcareous flagstones and schists, which from their fossils and position may be taken to represent the Ludlow rocks.

The Silurian strata of Norway are thus clearly divisible into an upper and a lower group, with an intermediate limestone loaded with *Pentamerus oblongus*, and corresponding, therefore, to the Woolhope or Horderly limestone of the British Isles: but these two groups constitute one inseparable and closely connected system, the uppermost beds of which, composed of calcareous sandstones containing *Leptaena lata*, a peculiar *Spirifer*, and a shell closely allied to *Terebratulula Wilsoni*, are overlaid in the mountainous tract called the Ringerigge (see annexed section), by red



quartzose sandstone and shale that forms a deposit of great thickness (perhaps 1000 feet), lithologically undistinguishable from the old red sandstone of the British Isles. Thus the beds of this latter group (the old red sandstone) broken through by great tabular masses of porphyry, are separated from the ancient gneiss on either side, and occupy a lofty tract in the centre of the trough, having the Christiania fjord on the one side, and the Steens fjord and Drammen on the other, both of which depressions are filled with the Silurian rocks in question.

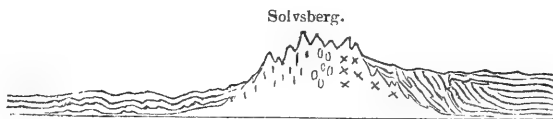
In the Steens fjord the symmetry with which the upper Silurian flagstones and tilestones rise out from beneath the great mass of the old red sandstone, is very striking; and in carrying the same section across to the gneiss range on the west bank of the Drammen, the upper calcareous coralline formation is separated from the black Silurian flags by the same limestone, containing *Pentamerus oblongus*, which forms the intermediate bed between the upper and lower Silurians in many parts of the British Isles. But whilst

* Among the fossils from the inferior members of the series (the lowest beds of which contain fucoids) are found the genus *Battus* or *Agnostus* with *Paradoxides* or *Olenus*, and in other beds *Trinucleus Caractaci*, *Asaphus Buchii*, and *A. tyrannus*, with various *Orthoceratites* and other chambered shells and some *Orthida*, including *Orthis alternata* and *O. virgata*; all forms highly characteristic of the Lower Silurian rocks in the British Isles. With these, and in still greater abundance, are found *Illænus crassicauda*, *Asaphus expansus*, and *Chætetes petropolitanus*, *Orthoceratites duplex*, and *Sphaeronites aurantium*, all of which specially distinguish the Lower Silurian rocks of Sweden and Russia.

there is an undoubted parallel between the different members of the Silurian rocks of Norway and those of the British Isles, they are in many parts, especially on the sides of the bays of Christiania and Drammen, so perforated by eruptive rocks of posterior age, that, except in such very typical localities as those of Steens fjord and Kroklevn, it is difficult to distinguish a clear order of superposition.

Metamorphosed Silurian Rocks of Norway.—Intending to revisit Scandinavia in company with my friend M. de Verneuil, and then to work out in greater detail the exact contents of each of the Silurian strata, I shall no longer dwell on that point, but proceed to describe some of the most striking effects produced on those beds by the eruption of the igneous rocks which traverse them. The general section will convey an adequate idea of these intrusions, a small portion of which only, as well as a limited number of the flexures and cracks of the sedimentary strata, are there represented.

It is sufficient for my present purpose to state, that whether consisting of granites, porphyry, greenstone, or hypersthene rock, these igneous masses all play the same part as the trap rocks, porphyries, modern granites, and syenites of the British Isles, sometimes producing great dislocation with little alteration, at other places very perceptible changes, and in extreme cases a complete metamorphosis of the invaded strata. Of the first of these results of intrusion, it is unnecessary to speak; nor, indeed, is it essential to dwell at great length upon the second, since the phenomena are completely analogous to thousands of examples in our own Isles, and other parts of the world. In the Silurian tract



In this diagram the peaks of Syenitic Greenstone (/), Greenstone (o), and Porphyry (x), are represented throwing off and altering the Lower Silurian rock on each side.

extending north-eastward from the Steens fjord to the insulated mountain called the Solsvberg, examples of greenstone, porphyry, and syenite, intruding upon the Silurian beds, are, indeed, countless. The Solsvberg, which lies to the east of the Lake Rands fjord, is the most prominent and loftiest of these eruptive masses which I visited. Rising to about 1200 feet above the adjacent lake, its summits are seen to consist in parts of a syenitic greenstone, with crystals of labradorite and hornblende, in others of coarse-grained greenstone, and in a third of porphyry; and its flanks are of black schist and impure limestone, which near the points of contact are in a highly compact and indurated condition, and are thrown up in vertical or dislocated masses, occasionally containing trilobites, orthoceratites, and fragments of other organic remains, all of Lower Silurian age.

In the lower undulating country to the south of that hill, the same strata (including the *Pentamerus* limestone) are cut through by many courses of eruptive rock, some of which (as at Velo) consist of a reddish rhombic porphyry, having a base of granite and compact felspar, and others of hornblendic greenstone, flanked by highly allied subcrystalline ferriferous red strata, which, at a little distance from the intruding masses, assume the aspect of the ordinary *red rab* of Pembrokeshire. The chief of these bands and dykes of eruptive matter (some of which having a felspathic base, are changed into crystals of felspar and lime) usually traverse the Silurian beds from N. N. E. to S. S. W.

Following these porphyritic and greenstone rocks to Klekken, they are seen in some places to cut through, and in others to throw up into domes the Silurian strata. Struck with the apparent multitude of these little undulations, and desirous of ascertaining what was the real geological equivalent of the band marked "*harte schiefer*" on the map of Keilhau, my friend Professor Forchhammer and myself made a traverse from the village of Klekken on the west to the mountain chalets of Hong on the east, where large masses of granitic and porphyritic rocks rise to the same table land as that of which the section (p. 469.) exposes a part. In the lower undulations we observed a number of greenstone dykes trending from E. by N. to W. by S., every little ridge being characterized by a nucleus of such rock, and its flanks composed of jet-black anthracitic schist, and some impure limestone. Parallel to these dykes and nearer to the mountain side, is a strong band of rhombic porphyry, whilst other dykes (apparently traversing those of which I have been speaking) constitute a network of intrusive matter.

Owing to the short time at our disposal, we could not then determine whether the rhombic porphyry or the greenstone were the last ejected, but our observations in the country of Ringerigge, where greenstone cuts through the porphyritic plateau, led us to conclude that as the porphyry was unquestionably formed posteriorly to the old red sandstone, so the greenstone was the most recent of these eruptive masses. As we ascended the mountain side, the calcareous shale and limestone which forms a mural and slightly altered mass in the valley with a strike conforming to the direction of the chief eruptive bosses (E. by N. to W. by S.), becomes more and more indurated, and in one place, where the beds resumed their prevalent strike of N. by E., and S. by W., they are cut through by transverse east and west dykes of greenstone. On approaching the summit called the Rong Stein or the summer pastures of the village of Hong, the sedimentary mass may there be considered as a great flap of the granitic and porphyritic mountain, and is then in a still more altered state, assuming what geologists used formerly to call a very ancient aspect. The schist becomes brittle, crystallised, and compact, and is the "*Harte Schiefer*" of Keilhau; whilst the calcareous nodules have disappeared, leaving cavities in the schist, which still distinctly mark the original lines

of deposit; until finally in parts still nearer the eruptive rocks the whole is a dense, compact, subcrystalline mass.

It was, therefore, evident that the "Harte Schiefer" of M. Keilhau, marked by that author by a distinct colour in his geological map, was nothing more than a portion of the lower Silurian shale with its overlying bands of *Pentamerus* limestone, which we had followed from Solvsberg by Velo to the tract between the falls of the Drammen and Steens fjord, and which, unaltered in the plain and considerably modified in the undulating grounds, had become metamorphic on the side of the granitic and porphyritic mountains.

Having passed over a considerable tract of ancient gneiss, which occupies all the region to the west of the Drammen river, we found, on traversing that river in a boat at Vigersund, a repetition of similar phenomena; for there the lower Silurian sandstone beneath the furoid shale (which is rarely seen in this region of Norway) is thrown up into vertical masses and converted into quartz rock in contact with a dyke of greenstone, whilst the alum schist which succeeds is traversed by a white porphyry, and is highly brittle and anthracitic.

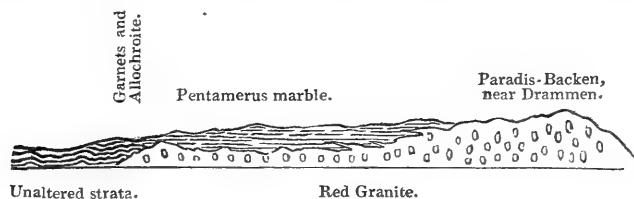
The same relations are, indeed, seen all along the frontier of the gneiss between Vigersund and the port of Drammen, quartz rock or altered lower Silurian sandstone, of which I shall speak at greater length when describing Sweden, there forming the lowest Silurian course, and being surmounted by black schists and flagstone with calcareous nodules, from some of which we obtained specimens of *Asaphus expansus* and *Orthoceratites*, &c.

To the north of the Drammen the Silurian escarpment is strikingly affected by the eruption of granite and greenstone, the latter apparently forming the lower boss near the town, the former rising into a little eminence at the foot of the hill side. We could, however, draw no sort of geological separation between the greenstone and the granite, as to their age or effects. The granite is indeed most distinctly seen to protrude through the sandstone, which in many parts folds over it as a cap or dome, and is of a red colour, and indented like quartz rock. Still higher up, the sides of the escarpment are composed of amygdaloidal trap, in which are included separate angular fragments of flags and sandstone, one of which 50 feet long, and 12 to 15 feet high, appears as a highly altered, reddish, micaceous flagstone.

In the next example which we visited, or that which occurs at the hamlet of Dielebeck, a few miles north of Drammen, the metamorphism of the strata has been carried to a greater extent than in any case previously cited. Rose-coloured, large-grained granite there occupies the hill called Paradis Backen, on the northern slope of which the limestone and shale repose in slightly inclined strata.

At this spot the limestone, in the beds of which at a certain distance from the granite the *Pentamerus oblongus* has been occasionally found, is in the state of marble; and the fact of its having

been formerly much laid open by quarries, has led to a thorough acquaintance with the nature of its junction with the granite.



Among other geologists, Professor Naumann of Saxony observed this junction some years ago, and showed that just in proportion to its contiguity to the granite, has the limestone been altered; *veins of granite* having actually been found by him *intruded into the calcareous mass*. Though such a junction was no longer visible, we had great satisfaction in observing the extent to which so large a mass of limestone (laid open in extensive quarries 40 to 50 feet deep) had passed into a state of marble, particularly in its lower parts, and still more in detecting in one of the depressions adjacent to the quarries, and not far from the intrusive rocks, portions of the limestone which were thickly impregnated with crystals of garnet, and other parts where the sandy shales and calcareous courses are welded as it were together, with few or no traces of bedding; the mass having assumed the aspect of a compact garnet rock similar to a variety with which I am acquainted in the Ural Mountains.*

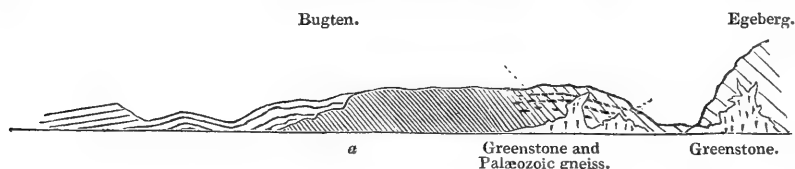
On receding from these promontories of granite, the strata resume their natural characters: the beds of limestone are clearly divided, other included Pentameri appear, the flinty slates become ordinary black schists, and the whole group, though never free from great undulations, resembling in this all the Silurian islands of the bay, puts on all the characters which are peculiar to it in Christiania fjord, to which I have now reconducted my readers, after a rapid traverse across the high plateau of Ringerigge, and a survey of the eruptive rocks as seen around its external edges.

Conversion of Lower Silurian Schist into mock Gneiss. — If the granite of Drammen has altered sandstone into quartz rock, and Pentamerus limestone into marble with garnets, the greenstones and porphyries of Christiania, particularly on the eastern side of the bay, have produced a still more remarkable change on fucoid shale, transforming it into a rock which might very well be mistaken for old Azoic gneiss.

The spot where I first observed this phenomenon in company with Professor Forchhammer, is on the sea-shore at the southern foot of the Egeberg, where a little promontory stands out in advance of the mountain of ancient gneiss, and juts out into the bay, in which there are several little islands as well as a low tongue of Silurian schists and flagstones.

* Some of this rock was in the mineral condition of "*Allochroite*," according to Professor Forchhammer.

Approaching the spot in a boat, it was interesting to observe the very gradual and perceptible change, from the unaltered schists and



a, Black alum schist passing into chlorite schist and gneiss.

b, Lower Silurian rocks.

flagstones of the low neck of land, to the highly contorted and metamorphosed masses which rise up into the little promontory. The flags and limestone being first contorted and deflected, are succeeded by black alum shale, in which is disseminated a great quantity of iron pyrites mostly in a decomposing state. Gradually this rock, in vertical strata, is seen to pass from the black shale (which is a fine alum schist on the other face of the Egeberg) into greenish micaceous schists, which, as they approach nearer to the mountain, and to the focus of eruptive greenstone, become more and more crystalline, until they might pass for a good primary schist, not easily distinguishable from much of the old gneiss of the adjacent country. In the upper portion of this mass, or that nearest to the black shale, the rock is loaded with little crystals of iron pyrites, evidently formed by an aggregation of the loose and scattered particles in the altered shale. In the most crystalline portion, however, or that which is nearest to the bosses of intrusive greenstone, are veins of the crystallised pyrites. A singular feature in this conjunction of appearances is, that long and slender veins of quartz radiate as it were throughout the rocks, traversing the greenstone and mock gneiss, and also passing from that into the black and contorted shale. I have specially described this spot, both because it affords the best evidence with which I am acquainted of the conversion of alum shale into a gneissose rock with chlorite, &c., and because the chemical process followed by nature in operating this change has been admirably explained by Professor Forchhammer, who has endeavoured to show that as no argillaceous schistose rock could undergo similar melting and metamorphosis without the medium of a flux, so there was potash existing in the alum-shale, derived from the decomposition of fucoids, and which, therefore, originally deposited in considerable masses in the rocks, had served as the flux whereby the whole mass was fused and metamorphosed.

In referring geologists to the paper by Professor Forchhammer on the conversion of fucoid alum shale into a gneissose rock, published in the volume for 1844 of the Reports of the British Association for the Advancement of Science, I ought to state that M. Forchhammer is quite as intimately persuaded as myself, that however such metamorphosis may have been brought about, there is no doubt that the converted palæozoic rock can never be mistaken, ex-

cept in isolated specimens, for the ancient Norwegian gneiss ; since the former, however much altered, can always be traced without any unconformable junction from the crystalline strata into a slightly altered rock, and then from that into wholly unaltered and fossiliferous Silurian bands. On the other hand, no such example of transition from the great masses of ancient gneiss into Silurian rocks has ever been seen in any part of Scandinavia ; and however an example like this, where the converted rock resembles the more ancient gneiss, might tend to mislead a young observer, I shall show in the sequel how these fucoid strata, or oldest Silurian rocks of other parts of Scandinavia, repose on previously formed gneissose rocks.

If some geologists should contend, that as fucoids are comparatively of rare occurrence in strata, the theory of Professor Forchhammer is not based on adequate data to account for more than a partial phenomenon, I beg entirely to dissent from such scepticism. No one can ever have looked at the forests of algæ and fuci which are living in many sea bottoms (and I was powerfully struck with their profusion in the deep and clear fjords of Norway), or have reflected on the enormous bands of such vegetables which extend through many degrees of latitude, as described by Mr. Lyell, without admitting that many, if not by far the greater portion of our sea-formed strata, which now constitute the chief masses of our continents, may have originally contained fucoids, although, from their ready decomposition, and the great changes which the sediments have undergone, distinct evidences of their existence are comparatively seldom to be met with. And, as in huge masses of the fucoid schists of Scandinavia, where the form of the vegetable has disappeared, the rock is only distinguished either by its anthracitic or bituminous qualities (parts of it being sometimes so carbonaceous as to be used as fuel for roasting the other portions of the alum slate), so I can very well conceive how many of the schists and slates of England, from the lower Silurian to the Lias and superior rocks inclusive, have derived their pyritous, aluminiferous, and often inflammable properties from the ancient diffusion therein of a large proportion of fucoids. The very seas in which the azoic rocks themselves were formed may in like manner have contained abundance of fucoids, whose decomposition may have afforded a flux for the metamorphism of those the most ancient deposits in the crust of the globe.

Passing, however, from these theoretical considerations, I will now merely add, that besides the case observed at the foot of the Egeberg, I also remarked what I conceive to be similar phenomena in the cliff on which the Agershuus, or fortress of Christiania is built. M. Von Buch directed my attention to what he considered to be an anomaly in the appearance of that singular outlier which is separated from the main mass of gneiss by a broad trough of Silurian schists and flagstones on which the town and environs stand. On examining the seaward face of this promontory, I found it to be also composed of black schists

and flagstones unquestionably of Silurian age, having, where not much fractured, the usual strike of N.N.E. and S.S.W., and cut through by masses of porphyry and greenstone. Near some points of contact, these schists are highly indurated, becoming almost a Lydian stone, with pyritous crystals; and in other larger masses, particularly those which form the north-western rock on which the north-western and southern bastions stand, the rock is a gneiss, which, folding round points of greenstone, can scarcely, if possibly, be mineralogically distinguished from the oldest gneiss in the country. In receding, on the contrary, a few paces only from the most metamorphosed parts, you pass into masses in which the lines of bedding and concretions are distinctly visible, though the whole are much broken up, dipping away to the E. and W. in truncated fragments of the harder flagstone, wedged unconformably into the surrounding matrix of schist. Transverse quartz veins are here nearly as abundant as in the example at Bugten near the Egeberg.

In taking leave of the sedimentary and metamorphic territory of Christiania, with its encircling mountains of older or azoic gneiss, I may state that, according to the views of modern geology, all the extensive tracts within that boundary, not merely in the Christiania fjord, but also in the fjords of Drammen, Steen, and Rand, and extending southwards to Frederiksvärn, compose parts of a great palæozoic basin, the base of which is the lowest Silurian fucoid band, and its summit the old red sandstone. This idea would, indeed, hardly strike any observer who looked at M. Keilhau's map; for, faithful as it is in respect to general boundaries, the varied colours with which he represents the different granites, porphyries, and greenstones within the basin, and the vast spaces overspread by those colours, necessarily withdraw the mind from true historical considerations to features purely mineralogical.

The truth then is, that in some parts of this palæozoic basin, the strata of Silurian and Devonian age are abundantly developed, though almost every where traversed by innumerable eruptive dykes, and thrown about in rapid undulations, whilst in other and still larger tracts, the eruptive rocks have usurped nearly the whole surface, leaving mere shreds and patches only of the original sedimentary masses which once occupied the basin. Thus, the granite which I have spoken of as piercing and metamorphosing the Silurian rocks of Drammen, rises into mountains, and extends over nearly the whole large promontory between Launig and Frederiksvärn, ranging down to the sea in low and gnarled headlands, exactly resembling those of Cornwall. Now, indeed, that we know these intrusive Norwegian rocks to be posterior to the old red sandstone, the analogy between them and the rocks of Devonshire and Cornwall is very nearly complete. In both countries eruptions have predominated, which I would venture to call "palæo-plutonic," to distinguish them from these more ancient granitic eruptions

which are subordinate and confined to the azoic rocks strictly so called. The latter, therefore, on the same principle, I would term 'Azo-plutonic.' In the construction of geological maps, there must, I conceive, be an adherence to the principle embodied in these names, if we desire to mark chronologically the changes which have affected the earth at successive periods. The necessity of this distinction between the older and more recent granites will be made still more manifest when I have described their relations in Sweden.

*Silurian Rocks of Sweden, and their Relation to the older Crystalline Rocks.**—In this notice it will be convenient first to describe the relations of the lower Silurian group to the subjacent crystalline rocks, and then say a few words concerning the fossils of the upper Silurian group of Gothland.

In the Hills of Hollaberg and Hunneberg to the east of the Falls of Trollhætten, which are covered by a thick mass of basaltic greenstone, one subordinate member only of the Silurian series is visible, namely, the alum-slate; but no one who knows from numerous other sections that this band is very near the Silurian base, can glance his eye over the lower adjacent lands, all composed of gneiss and granitic rocks, or look up from the latter as they appear on the banks of the river, near the Falls of Trollhætten, without being convinced that the horizontal band of black schistose Silurian rock lies high above the crystalline granitic rocks of the low country, though the absolute junction of the two is hidden by a talus of detritus.

Advancing to the next Silurian oasis at Kinnekulle and the hills of Billingen, the same general relations of a *low surrounding country of gneiss and granite, to high tabular plateaux of horizontal Silurian strata*, usually capped by trap, present themselves to the traveller. In ascending the hills of Kinnekulle, from the low gneissose country of Lidköping, he is no sooner above the low level of those crystalline rocks, than he meets with a terrace composed of quartzose sandstone, already mentioned as frequently forming the lowest Silurian stratum in Scandinavia. This rock, here arranged in beds from a few inches to a foot and a half thick, is light-grey, whitish and fine-grained, in parts freckled with ferruginous stains, and assumes at intervals a quartzose character, with divisions of chloritic shale. Its lowest beds, or those which, as we shall presently show, rest upon the adjacent gneiss of the valleys, are not here visible, owing to a talus of detritus, but in those which are visible, were found branching fucoid-like bodies. This sandstone is, in fact, seen to constitute the prevalent base of all the Silurian strata, and in the hill of Kinnekulle is surmounted, first, by the black alum schists and limestone; next by red Orthoceratite limestone; and, lastly, by Graptolite schists with some calcareous courses and Orthoceratites. Though irregularly denuded over a very considerable area, the Orthoceratite limestone

* See "Russia and the Ural Mountains," &c., *ante cit.* p. 15.

occupies a prominent step on the sides of the plateau, and standing out high above the surrounding gneiss, is in its turn covered by black schists, through which basaltic trap has pierced, occupying only a small upper portion of the central part of the tract. In descending from this summit we were much struck with the perfect symmetry of the Lower Silurian beds. To the north, or on the side of the Wettern lake, the crystalline and gneissose rocks being in a depression, the fucoid sandstone ranges down to the water edge, surmounted by the alum-slates, but on the south-eastern face of the hill of Kinnekulle the gneiss is again seen to present exactly the same inferior relations to the lower sandstone as on the western side, and the Orthoceratite limestone is there strikingly developed by extensive quarries, which form the first great step-like terrace between the basalt-capped schists above and the low country of gneiss beneath. Descending from these limestones, and passing over beds of alum-slate and black limestone, the fucoid sandstone is seen in horizontal masses, perfectly conformable to all the overlying strata, and distinctly superposed to the gneiss below ; and indeed although the absolute junction of the sandstone and gneiss is not seen, the two rocks are within a hundred paces of each other, and without the slightest indication of any other substance between them. The gneiss also here is not merely in a lower position than the contiguous sandstone, but, besides its crystalline structure, is at once seen to belong to rocks of an entirely different class, and to be quite independent of the overlying Silurian formation, so that the one must have assumed its direction and structure before the other was accumulated.

It appears therefore that the gneiss, including many varieties, must be considered the fundamental rock of Sweden, which existed and was even highly inclined before the very lowest Silurian beds began to be formed.

If however, after examining the section of Kinnekulle, there could be any doubt on this point, it would be dispelled by what appears in other localities, where the lowest of the Silurian strata are not only absolutely superimposed on the granitic gneiss, but are proved to have been derived from it, and are composed of its very materials. Examples of this phenomenon may be seen at Lugnos, near the northern end of the Billingen Hills, where the Lower Silurian beds (as at Kinnekulle), being deprived of their cover of basalt, which has protected them from denudation over a considerable area to the south, are worn down, so as only to exhibit their lowest portion, the alum-slate being partially visible above the slopes of the rising ground, and the fucoid sandstone lying beneath it.

Here, at least, there can be no ambiguity ; for the whole of the adjacent low tract is composed of rolling hillocks of granite or granitic gneiss, which assume exactly that appearance of bell-shaped masses so happily illustrated by M. von Buch.

Again, in exploring the eastern shore of the great Wettern Lake,

to the south of Wadstena, among other phenomena of great interest, we found that along the steep shores of the Omberg, one of the few hills in Southern Sweden where the granitic gneiss occupies a tract of any considerable height, the relations of the Lower Silurian strata are, if possible, still more strongly indicative of their having been derived from the adjacent pre-existing crystalline rocks.

The Orthoceratite limestone is largely quarried at the village of Borghamm, near the northern end of the Omberg; but by coasting that mountain in a boat along its western face, the granitic rock of which it is composed is seen to occupy the whole surface for some distance, in cliffs rising to 400 or 500 feet above the lake. In about a mile, however, broken masses of the Lower Silurian rocks occur in nearly vertical positions, plastered as it were against the great wall of crystalline rock. Still further on, or southwards, the chief mass of granitic gneiss retires somewhat inland, laying open coombs upon its inclined surface, and in these are very considerable masses of Lower Silurian strata with an occasional Orthoceratite, but with little calcareous matter and few fossils. These strata occupy a considerable thickness, both in a slightly inclined, almost horizontal terrace, and also in vertical and highly inclined positions. The inclined strata are chiefly composed of soft argillaceous shale entirely unaltered, even when they are in absolute contact with the granitic rocks, and in them, and also in certain alternating courses of calcareous grit, are many included small pebbles and fragments of the crystalline rock. Across the edges of one group only of these beds near their southern extremity, where the mass of the granitic rocks retires inland, and which are inclined at about 35° to the north for upwards of 800 paces, their lower part consisting of black shale (alum-slate) wholly unaltered, we came to the lower fucoid sandstone. Here again there could be no misgivings; for this sandstone having been considerably eroded and worn away by the stormy action of the waters of the lake, the lower granitic gneiss beneath it has been exposed as a nucleus, around which the white, sandy and regenerated sandstone has been wrapped, and is still in a wholly unaltered state!

These facts completely demonstrate what we are contending for, that the granitic gneiss and associated rocks of Sweden formed the solid materials of that country before the earliest vestiges of palæozoic deposits were called into existence. They further prove, that as the Lower Silurian strata in question which are actually adherent to the granitic rocks, though highly dislocated, occur in the state of soft shale and unaltered impure limestone and sandstone, the crystalline ridge of the Omberg must have been upheaved as a hard and solidified mass, long after the period when it had undergone the fusion and metamorphism which gave to these ancient slaty rocks their crystalline aspect.

Other phenomena, proving that the lowest Silurian sandstone of these tracts has been formed out of the ancient crystalline

rocks, are also to be found in many other parts of Sweden, and we particularly noted them still further to the south, on the high eastern banks and slopes of the Wettern Lake near Grenna, where, as well as in the large isle of Visings, the strata are composed of a sandstone which is simply a continuation of the base of the lowest Silurian stratum, its red colour being derived from adjacent red felspathic and quartzose rocks out of which it has been formed and on which it rests. Judging from what we observed in some districts we should say that this sandstone, although the lowest member of the Silurian system over large tracts in Vestrogothia and Ostrogothia, is not so universally in Sweden.

In certain quarries of argillaceous limestone at Freberga, to the north of Motala, we met with beds absolutely loaded with *Echinospærites*, of the same species as those near St. Petersburg. They are there clustered together like bundles of enormous grapes, and are associated with one of the small *Orthidæ* so common in the Russian deposits of the same age. Here again the beds, though entirely unaltered, are tilted at the high angle of 70° to the north, in the proximity of a hill of ancient granitic or syenitic rock, which had doubtless been heaved up *en masse* like the Omberg, whilst in all the lower flat beyond the slope of the limestone hillocks, and extending for many miles along the north-western shores of Wettern See, the lower or fucoid sandstone lies in grand horizontal sheets, and is extensively quarried as a building stone.

The total absence, with very few exceptions, of all Upper Silurian rocks in the main land of Sweden, and the fact of the existence of such rocks exclusively in Gothland, being well-known by the examination of fossils, it was not considered necessary to visit this latter island. The chief rock in it is a limestone very similar to that of the upper deposits of Christiania, and is loaded with corals, many of which, including *Catenipora escharoides*, *Favosites labyrinthica*, *F. gothlandica*, are well known species in the Wenlock and Dudley limestone of England. With these are associated *Leptæna depressa*, *L. euglypha*, *Atrypa tumida*, *Pentamerus* (*Atrypa*) *galeatus*, *P. conchidium*, *Delthyris cyrtæna* (*Spirifer radiatus*), *Terebratula Wilsoni* Sow. (*T. lacunosa* of the Swedish authors), *T. marginalis* Dalm. (*T. imbricata* Sil. Syst.), *T. reticularis* Linn. (Silur. variety of *T. prisca*), *T. nucula*, *T. plicatella* Dal., *Euomphalus sulcatus* His., *Posidonia alata*, *Avicula retroflexa* His., *Tellina prisca*, *Orthoceratites communis* Wahl. (*O. Ludense* Sil. Syst.), *O. imbricatus* Wahl., *O. annulatus* His. (*O. ibex* Sil. Syst.), *O. annulatus* Sow. (*O. undulatus* His.), *Phragmoceras*, *Lituities*, *Calymene Blumenbachii*, *C. variolaris* Brong., *Asaphus caudatus*, and a number of other Trilobites, among which is a rare example of the genus *Brontes* (Goldfuss).*

* We also observed among other Crinoidea the remarkable *Hypanthocrinites decorus* as well as the *Actinocrinites moniliformis* of Dudley.

The coincidence of many of these fossils with those published as Upper Silurian types in England is so truly remarkable, that no sort of doubt can be thrown on the inference, that the rocks in the two countries are of exactly the same age. The actual examination of the fossils has also enabled us to see, that certain British species which, judging from the published figures of Hisinger, were supposed to be distinct, are, in fact, identical with forms previously named by that author, whose terms will necessarily in all such cases be adopted.

Whilst the whole Gothlandian group is thus unquestionably proved to be Upper Silurian, a large part being undoubtedly in the exact parallel of the Wenlock limestone, we might (judging from certain fossils, such as the *Avicula retroflexa* and a species of *Brontes**, both found with certain Orthoceratites in a sandy rock at Mount Homberg in the southern part of the island) be led to think, that the true equivalent of the Ludlow rocks is also there present. This is, indeed, rendered highly probable from what is found to be the case in the Russian island of Oesel.

In the Swedish Upper Silurian group there are, indeed, a few species unknown to English geologists. But even these, though wanting in England, are found in rocks of the same age in other countries. Such, for example, is that peculiar shell the *Cytherina Baltica*, or a variety of it, which has been detected in Normandy and Brittany, and also in the Timan range of north-eastern Russia. Such also is the *Posidonia alata*, which is, if we mistake not, a fossil of the Clinton division of the Silurian rocks of North America. We cannot make the last allusion without observing, that several of the species enumerated, viz. *Leptæna depressa*, *L. euglypha*, *Atrypa tumida*, *Pentamerus galeatus*, *Orthis elegantula*, *Delthyris cyrtæna*, *D. sulcata*, *Avicula retroflexa* and *Hypanthocrinites decorus*, as well as *Calymene Blumenbachi* and other Trilobites, together with many corals, are identical, not only with English but also with North American species of the Upper Silurian rocks,—a striking illustration of the wide diffusion of similar conditions in the early stages of the formation of the earth's surface.

To whatever extent, therefore, future researches may prove that English subdivisions are practicable in it, the Gothlandian group is at any rate a most unequivocal example of true Upper Silurian types, which in Sweden are quite as distinct from those of the Lower Silurian rocks before described, as in the best known districts of the British Isles.

Silurian Rocks of the Baltic Governments of Russia. Lower Silurian at once covered by Devonian Strata—Upper Silurian of the Isles of Oesel and Dago.—Referring to a forthcoming work on Russia and the Ural mountains for details concerning the Silurian rocks of the Baltic provinces of the Empire, I will now

* Though not published in the Silurian System, the genus *Brontes* has been found by Dr. Lloyd in the Ludlow rocks, and even in their lower division. The genus is, therefore, common to the Upper Silurian and Lower Devonian strata.

simply state some broad facts with which I became better acquainted on my last visit to St. Petersburg. Previously, indeed, to that visit, my colleagues and myself had convinced ourselves that all or nearly all the Silurian deposits in the governments of St. Petersburg and Reval belonged to the Lower Silurian group only, an inference derived both from a more correct examination of these fossils than had been made when the earlier communications on this subject were made to the Geological Society (Proceedings, vol. iii. p. 398. 717.,) and from a better acquaintance with the Scandinavian palæozoic succession, which, in reference to the lowest group, is of great importance, by exhibiting an intermixture of well-known English Lower Silurian types with forms abundantly common to that country and Russia. In this manner, though the British typical species thin out and decrease in number, as the deposits are followed from west to east, their place in the series is distinctly and unequivocally preserved.

As a whole, then, I now beg to state, that the Silurian deposits of the Baltic governments of Russia, which consist in ascending order of (1.) clay, (2.) Ungulite sandstone, (3.) bituminous schist, and (4.) Pleta or Orthoceratite limestone, unquestionably constitute the very same group as that which has been shown to be Lower Silurian on the main land of Sweden; for amid certain new forms they are charged with the same characteristic fossils—*Asaphus expansus*, *Illænus crassicauda*, *Orthoceratites duplex*, *Echinosphærites* in abundance, and the coral *Chætetes petropolitanus*. When, however, we enter into details, there are considerable variations both in mineral and zoological development. Thus, whilst in Sweden the lowest stratum is a sandstone, in Russia it is a shale of great thickness; though in both tracts the analogy is preserved by the lowest band containing fucoids only. The second Russian stratum or Ungulite sandstone, is peculiar to Russia in containing that remarkable horny shell, the *Obolus* of Eichwald or *Unquolite* of Pander, but the overlying *pleta* limestone or great centre of animal remains is full of the characteristic shells of the lower limestone of Scandinavia. And here it is curious to observe, how in receding from our typical regions in Britain certain generic and specific forms gradually disappear, though the families of fossils remain the same. Thus the two most common of the Lower Silurian trilobites of England, the *Asaphus Buchii* and *Asaphus tyrannus*, which are not unfrequent in Norway, begin to be scarce in Sweden, and in Russia have only been very rarely discovered.* The *Trinucleus*, so very prolific in Great Britain,

* Professor Eichwald had previously observed that the *Asaphus dilatatus*, which is, we conceive, identical with the trilobite called *Asaphus Buchii* of the British Isles, occurs at Oduisholm, an isle adjacent to Esthonia. More recently H.I.H. the Duke of Leuchtenberg has found both the *A. Buchii* and *A. tyrannus* in the quarries of Grafskaya Slavenka, to the south of Czarskoe Celo, where they are associated with many other typical Lower Silurian fossils, and some new genera and species which the Prince has named. (See "Beschreibung einer neuen Thierreste aus den silurischen Kalk-schichten von Tzarskojé Celo von Maximilian Herzog von Leuchtenberg.")

is scarce in Scandinavia, and as yet has never been discovered in Russia. On the other hand, forms which are rare in England, such as the *Illænus crassicauda* (published as the *I. perovalis* in the Silurian system) and others, become very common both in Scandinavia and Russia. Again, *Orthoceratites*, usually so scarce in the lower division of the English series, are most prodigiously disseminated through the deposits of the same age both in Scandinavia and Russia; while the *Orthidæ*, with simple ribs, are here as characteristic of the Lower Silurian age as in England, and among them is the *Orthis calligramma*, which occurs in some of the very oldest strata of N. Wales.

In the Russian Baltic provinces, as in Scandinavia and England, the Lower Silurian group is terminated in the ascending order by a limestone containing *Pentamerus*, in which some of the Upper Silurian corals begin to show themselves, but the prevailing species, though closely approaching to the *P. oblongus* of England and Norway, is one which must be considered a new species, and which we formerly named *P. Letticans*, from the tract in which we found it.*

Numerous sections to the south of Czarskoe Celo and on the rivers Ishora, Volkof, Siass, &c. demonstrate that the Lower Silurian group, as clearly defined by its fossils, and without the presence even of the intermediate band of *Pentamerus* limestone, is at once overlaid by true Devonian strata laden with ichthyolites. Such a junction was formerly described on the river Volkof, but at that period the precise equivalent of the underlying Silurian rock was not pointed out. In my last visit to St. Petersburg, I visited one of these junctions in company with my friends, Count Keyserling and M. Wörth, who had shortly before described it in a memoir read before the Mineralogical Society of that capital. The Pleta or *Orthoceratite* limestone, which occupies the great plateau of Czarskoe Celo, is surmounted, to the south, at the village of Ontolova, by reddish sandy and marly beds, in which a few fishes' scales were found by M. Wörth; and on following these beds up the course of the Slavenka, to the villages of Marina and Porites, they are seen to become hard cream-coloured marlstones in which the remains of *Ichthyolites* are most abundant.†

These remains have, in the hands of M. Agassiz, to whom I referred them, thrown much additional light on the Devonian fauna. Among them there are, it is true, certain forms belonging to genera known in the Old Red Sandstone of Scotland and England, but these are accompanied by several genera new to

* Since our former notices were read it has been published as *Pentamerus borealis* by Eichwald.

† In his accurate *coup d'œil* of the environs of St. Petersburg, Strangways was the first who had noticed and even marked in his map this *red earth* on the Slavenka; but he found no fossils in it, and at the period when he wrote could not be expected to compare it with the Old Red Sandstone.

science, and some which had hitherto never been found lower than the carboniferous limestone. Of the genus *Onchus*, found by myself in the Old Red Sandstone of Worcestershire (see Sil. System, pp. 589, 596.) two species are described by M. Agassiz as the *Onchus heterogyrus* and *O. sublaevis*, and of the new genus *Byssacanthus* to which the *Onchus arcuatus* of Bromyard in Herefordshire is now referred, that author describes two Russian species, *B. crenulatus* and *B. laevis*. From the other placoids from this locality Professor Agassiz determines the new genera *Homacanthus*, *Hoplacanthus*, *Odontocanthus* (one of the latter having previously been called by him a *Ctenoptychius*), *Narcodes*, and *Naulos*.

Among the Cestraciant family of Placoids he places two of the Russian forms in the genus *Ctenodus*, no species of which has hitherto been found lower than the Carboniferous system. Of this genus, two new and very remarkable species occur in the lower Devonian beds of Russia, and these have been named *Ctenodus Keyserlingii* and *C. Wörthii*, after Count Keyserling and Dr. Wörth, who discovered them. Among the family of Hybodonts, M. Agassiz has recognised the new genus *Cladodus* and others of which I have yet received no account from him.

As these ichthyolites are about to be published in his "Monographie des Poissons du Système Devonien," and as their relations will be also illustrated by a short description of the fossils in the work on Russia already referred to, it is unnecessary that I should further advert to them. As a geologist, however, I may be permitted to remark, that most of the genera being entirely unknown in the overlying deposits (the underlying Silurian deposits of Russia never having afforded the trace of a fossil fish), and as the species of *Ctenodus* are entirely distinct from any forms of that genus in the carboniferous limestone, these fossils strongly sustain the view of M. Agassiz, that each great formation or system has been the tomb of a peculiar group of fishes.

On the river Siass, my colleague, Count Keyserling, has observed a succession from Lower Silurian to Devonian, analogous to that which I have just described. The lower beds, consisting of arenaceous limestone with small white concretions, and calcareous flags alternating with red and green marls, contain numerous true lower Silurian types, including the *Orthis calligramma* Dalm., *O. plana*, *O. inflexa*, and *O. extensa* of Pander, together with *Asaphus expansus*, *Orthoceratites vaginatus*, *Favosites petropolitani*, &c. These are at once, and quite conformably, overlaid by other calcareous flags, and also with red and yellowish marls, in which certain typical shells never yet found in the upper Silurian rocks, but eminently characteristic of Devonian strata, are intermixed with true Devonian ichthyolites. Among the shells are, *Orthis striatula* Schlot. *Terebratula Livonica* Von Buch, *Spirifer muralis* nob., *Orthoceras cochleatum*, and *Serpula omphalotes*, whilst the fishes belong to the genus *Dendrodus* and the family of *Cocosteini*. This union in the very same beds of the ichthyolites

of the Scottish and English Old Red Sandstone with the shells of Devonshire and the Eifel, we had, indeed, previously observed in other parts of Russia; and I will now only add that, since the former abstracts on Russia were published, the question has been unequivocally set at rest even in Western Europe. In a recent letter, M. de Verneuil informs me that in a collection which he made at Gerolstein in the Eifel, M. Vogt, the friend and assistant of Agassiz, has distinctly recognised the ichthyolites *Coccosteus* and *Osteolepis*.

To persons not well acquainted with the palæozoic succession the apparent passage above alluded to (for the overlying Devonian beds really much resemble the lower Silurian beneath them) might seem to be very anomalous; but extended examination, and a due consideration of the causes which have operated in elevating and depressing different portions of the country in question, remove the difficulty. Thus, for example, in advancing from the government of St. Petersburg, on the east, to Lithuania and the shores of the Reval on the west, the true lower Silurian group, as above defined, is first found to be overlaid by the *Pentamerus* limestone; the uppermost member of the lower group which in St. Petersburg and to the east is entirely absent. This overlying band, in which the *Pentamerus borealis* Eichw., is intermixed with a few shells common to the lower and upper groups, ranges by Wissenstein, Oberpahlen, Shavli, Pocroo, and other places; and finally, though no true upper Silurian rocks occur on the main land, they are clearly and copiously exhibited in the isles of Oesel and Dago. In these islands there is not only a full development of most of the corals of Wenlock and Dudley, but also of many shells, which, entirely distinct from those of the lower group, are to a great extent the same as those which characterise the Wenlock and Ludlow rocks of the British Isles, as appears by the following list, for which I am indebted to M. Pander:—*Catenipora escharoides*, *C. labyrinthica*, *F. Gothlandica*, *F. basaltica*, *F. polymorpha*, *Syringopora reticulata*, *Aulopora serpens*, *A. conglomerata*, *Millepora repens*, *Astræa Cyathophyllum*, &c., *Orthocera lineatus*, *Tentaculites annulatus*, *Calymene Blumenbachii* var. *pulchella*, *Terebratula diadonta*, *T. tumida*, *T. canalis*, *Atrypa depressa*, *A. reticularis*, *A. affinis*, *A. didyma*, *Orthis orbicularis*, *Delthyris sulcata*, *Avicula reticulata*, *Mya rotundata*, *Cardium striatum*, *Cyathocrinites*.

This list indicates, not merely the existence of Wenlock and Ludlow rocks, but also of the very uppermost beds of the whole Silurian system, or those tilestones that form a passage into the Old Red Sandstone, and which I formerly connected with that deposit, but which for several years I have considered with Professor Sedgwick, Professor Phillips, &c., as the upper termination of the Silurian system. For in the uppermost strata are found *Orthis orbicularis*, *Turritella obsoleta*, and *Turbo Williamsi*, all published British species of the highest Ludlow beds.

Although in Norway, therefore, there is a consecutive succession from lower Silurian through upper Silurian to the Old Red Sandstone inclusive, the continents of Sweden and Russia (at least that central portion of Sweden which I examined), are void of any true upper Silurian strata; the latter being confined, as far as I now know, to the Isle of Gothland on the one side, and the isles of Dago and Oesel on the other. These facts can, it appears to me, be best explained by supposing that these continental areas were elevated above the waters after the completion of the lower Silurian beds, which were thus placed beyond the influence of the depository action under which the rocks of the Baltic Isles and of Norway were accumulated; and also that after their accumulation, the Swedish continent remaining stable, the Russian masses were subjected to a broad, equable, and general depression beneath the sea, whereby the Devonian strata were conformably superposed to the Lower Silurian.

At the same time it is difficult to conceive that such extensive operations of upheaval and depression could have taken place without occasioning some dislocations. In describing Sweden I have already adverted to such, proving that, although the lower Silurian rocks of that region are for the most part horizontal, still there are tracts wherein they have been considerably deranged. And even in the Baltic provinces of Russia, which lie at so low a level above the sea, and in which no intrusive rocks are visible, there are transverse dislocations, the importance of which must not be passed over in coming to a right conclusion on this subject. I will therefore give a brief description of the nature of the junction of the Silurian strata, along their northern or Finnish and Lappish frontier, and after referring to the eruptions by which they have been there affected, will show how such operations and their accompanying elevations have extended their influence by producing transverse dislocations in the slightly consolidated lower Silurian rocks of the Baltic governments of Russia.

When viewing the great features of the earth, the geologist who compares the northern frontier of the palæozoic deposits of Scandinavia and Russia with that of British North America, recently described before this Society by Captain Bayfield*, cannot avoid being struck with the great similarity of succession in these two vast regions. In both the general range of the rocks is from S. W. to N. E., in both the same type of lower Silurian deposits occurs, and rests upon more ancient crystalline rocks; and in both are these strata succeeded in similar ascending order by upper Silurian, Devonian, and Carboniferous deposits. We may still further pursue the analogy by stating that in both regions great sheets of water range more or less along the older frontier line, and lastly, that in both large quantities of erratic blocks have been transported from N. to S., or from N. N. W. to S. S. E.

* See *antè*, p. 450.

In respect to the close parallelism of the different sedimentary masses of the two continents, I must refer to my opinions and those of my coadjutors in our forthcoming work, and will now merely say that as the succession in N. America has had its base line defined for about 2000 miles, so do the observations of myself and friends apply in the same general manner to an extent not far short of that space, or from the western headlands of Norway to those which separate the White Sea from the glacial ocean.

In Sweden, as has been shown, the absolute junction of the lower Silurian strata with the pre-existing crystalline rocks, is quite as clear as it can be in any part of N. America, but it is not so in Finland or Russia, where two powerful causes prevent our making the necessary observations. The first of these is the protrusion of much eruptive matter, and the consequent metamorphism of the conterminous strata; the other the prodigious accumulations of erratic blocks and detritus which obscure the fundamental rocks. It is not my intention to enter on this occasion into any details respecting either of these operations, which are treated of elsewhere, but merely to call attention to some great physical features along this frontier line, and to explain the probable causes of their production.

On inspecting the geological map of Russia, which is now published, it will be seen that, excluding the Gulf of Bothnia, the frontier line, of which I am now speaking, is marked by a great line of waters from S. W. to N. E. The Gulf of Finland is, in truth, but the north-eastern prolongation of the Baltic, and the White Sea is the north-eastern termination of this great and extended line of fissure; whilst intermediate between these two marine gulfs, lie the enormous freshwater lakes of Ladoga and Onega. On further inspecting the map, we are struck with the fact that the longer axis of each of these two great freshwater lakes is at right angles to the main direction of the rocks, and of the White Sea and Finland Gulf; and, further, that a multitude, we may say thousands of minor lakes in Finland, Carelia, and Lapland, are parallel to the great lakes, and also, consequently, transverse to the general bearing of the sedimentary masses in their relation to the subjacent crystalline rocks. Pursuing the inquiry, we see that other gulfs, some occupied by salt-water, as that of Riga in the Baltic, and those of Onega, Kandalaska, and Archangel in the White Sea, are also transverse in the same sense.

Let us then inquire if the structure and geological phenomena of the region will help us to explain such geographical outlines.

In a former communication I briefly pointed out the chief relations of the rocks on the banks of the great lake Onega, and showed, that wherever the eruptive matter (whether in the form of greenstone, syenite, or trappean conglomerate) had come to the surface, it had formed bands parallel to the great lake Onega, and that in the vicinity of such eruptions Silurian limestones had been metamorphosed into marble, and soft sandstones (which at some distance from the eruptions contained Devonian fossils)

into hard siliceous and quartzose rocks. These facts, and the coincidence of the form of the lakes with the outlines of the land, as determined by eruptive forces, led me to conclude that the one had been produced at the same time as the other ; or in other words, that the extravasation of so much igneous matter, or in its absence the upheaval of so much of the solid strata, had occasioned corresponding lateral and parallel depressions. This idea is supported by a general review of all the phenomena along the great frontier line in question, the whole of which afford, I think, a striking confirmation, and, on a very grand scale, of the theory worked out by Mr. Hopkins in the British Isles, from the close examination of smaller areas.

In the first place it is clearly determined by the general strike or bearing of the older palæozoic deposits and the boundary which they form with the Azoic rocks on the one side, and with overlying systems on the other, that the great line of their upheaval has been from S. W. to N. E., or rather, more correctly speaking, that they occupy a portion of a grand curve which has accommodated itself to the subjacent crystalline mass on which their lower edges rest—the direction of the Gulf of Finland being from W.S.W. to E.N.E., and that of the White Sea from S.W. to N. E. To this line so defined, the Silurian, Devonian and Carboniferous deposits strictly conform. The longitudinal upheaval of these deposits has, I conceive, been the chief original cause of the formation of the Gulf of Finland and the channel of the White Sea. These great depressions have been, in fact, produced along the line of junction of the sedimentary deposits with the crystalline rocks, or just where we might look for a physical separation at that period when the crust of the earth was subjected to great movements. Now, according to the mathematical demonstrations of Mr. Hopkins, no great portions of the solid crust of the globe could be upheaved without being accompanied or followed by great transverse rents ; just such as those that appear at so many intervals along the line we are considering. And if, as we may believe, the original elevation was due to the expansive power of intense heat, and gases struggling to reach the surface, so may we well imagine that where the action was the most powerful, and the cracks the deepest, such action would give vent to linear bands of molten matter that would rise up and form ridges similar to those accompanying the transverse Russian lakes. I was strongly confirmed in the adoption of this view by my last excursion to St. Petersburg. The Gulf of Finland itself exhibits clear evidences of emission of plutonic matter transverse to its chief axis in four small isles, composed of porphyry and greenstone rocks ; for though these isles trend on the whole parallel to the axis of the gulf, or from W.S.W. to E.N.E., the rocks, of which they are severally composed, have been erupted athwart this line, or from N.N.W. to S. S. E. This is best exhibited in the chief of these islands, called Hochland, which, rising to a height of about 600 feet above the sea, and stretching for a few

miles from S. S. E. to N. N. W., in the form of an elongated rugged ellipse, is chiefly composed of porphyry, on the shoulders of which are various patches of metamorphosed limestone and sandstone, thus presenting the most complete analogy to the phenomena of Petroyavodsk and the Lake Onega.

Now if such elevating forces had really produced abundant transverse fissures along the chief line of upheaval, or near the junction of the palæozoic and azoic rocks, we might naturally expect that their effects would be extended for some distance to the south and south-east, or in other words, into the conterminous sedimentary deposits, even in those tracts where no eruptive masses rend the surface, and where, owing to the repression of such eruptions, the original strata are in a very slightly coherent and unsolidified condition. And such is the case. If I were to point to general features only, it might indeed suffice to show that the rivers Narva, Luga, Ishora, Tosna, Volkof, and Siass, flow through chasms which are in fact fissures in the Silurian limestone, all more or less transverse to the strike of these strata, and coincident with the direction of the porphyries and trap rocks of the northern frontier, and all the northern lakes. Again, the long lake of Peipus, ranging from N. W. to S. E., is as near as possible at right angles to the major axis of the Gulf of Finland, and parallel to the direction of Hochland. Without, however, appealing to these general physical evidences, the effects of such transverse dislocation can be clearly traced even in the usually horizontal and unsolidified Silurian rocks in the immediate vicinity of St. Petersburg. On a former occasion, when speaking of the general horizontality and broad undulations of the palæozoic rocks of the low plateaux and plains of Russia, I still contended that certain breaks and contortions in the environs of Czarskoe Celo, or between that place and Palkovka, could not be referred (as M. Pander had supposed) to local subsidences caused by the spontaneous decomposition of pyritous schist on which the limestone rests, but must have resulted from those general causes of disruption which are so common in our own country, and indeed in nearly every part of the globe. In again calling the notice of the Society to these dislocations on the Palkovka brook, I can now give additional facts which so corroborate my former opinion, that no sort of doubt can be attached to it. The little brook of Palkovka is one of those streams which, escaping from the calcareous plateau of Czarskoe Celo, lays open on its banks beneath the village of Pulkova, first a great arch of the strata, next breaks and faults, and then masses of limestone more or less horizontal, from beneath which the Ungulite sandstone and lower shale are brought out in highly inclined strata. Examining the banks of another brook which flows through similar strata, by the village Popofka, at not less than 15 or 20 versts to the S. S. E. of the former, and therefore in a line directly transverse to the general bearing of these Silurian rocks, I found the phenomena so nearly the same, that my old section of Palkovka might really have been applied to

Popofka, thus demonstrating that wherever these usually horizontal strata have been really affected by a line of transverse fissure, their effects are by no means limited, but have extended athwart the sedimentary masses for considerable spaces.

In truth this is just what we might expect to see at intervals, even in sediments like these, which, on the whole, have been so equally upheaved and depressed, that, as before observed, the lower Silurian are conformably overlaid by Devonian beds—the relative age of the masses being alone determinable through a close and rigid examination of the organic remains. In general, however, such abrupt curvatures and breaks are very rare, broad undulations only being the predominant features of movement in the unaltered palæozoic deposits of Russia. This general horizontality of the strata was formerly sufficiently dwelt upon, and it was even shown that limestones of the Permian age, on the Vaga and the Dwina of north-eastern Russia, are so perfectly conformable to certain pleistocene deposits, that a person unacquainted with organic remains might suppose the upper palæozoic rock to have been there actually succeeded without any interval by those accumulations in which the shells are to a great extent undistinguishable from those now living in the sea. Such very conformable appositions of strata of different age are however most apparent wherever the country is flat, and the deviations from such rules are usually found where the ground rises. Thus the plateau of Czarskoe Celo, with its conterminous hills of Duderhof, is high in relation to the adjacent plains. Thus, again, in the Valdai Hills, which constitute the only considerable elevation in the region south of St. Petersburg, such transverse fissures are still more striking in the carboniferous limestone, though difficult to observe from the great masses of superficial detritus; thus seeming to prove that in proportion to the strain to which the strata were exposed in the process of elevation, so were they disrupted at right angles to the chief line of tension. After these allusions to the probable connection between the transverse fissures and breaks observable in the palæozoic strata of the Baltic provinces of Russia, and their elevation, I will conclude this memoir by stating as one result of the examination of the fossils of Scandinavia, that as the lowest fossiliferous rocks of that tract are unequivocally of the same age as the lower Silurian rocks of Great Britain and America, so the deposits which occupy the governments of St. Petersburg and Reval are the same as those of the continent of Sweden; in the latter country (I speak now of its central mass) no Upper Silurian having yet been discovered.

In both countries it would appear (the central mass of Sweden only being alluded to) that this group, proved to be protozoic by its having been deposited on antecedent crystalline and azoic rocks, is uncovered by Upper Silurian, though the latter deposit is copiously and unequivocally exhibited in the great island of Gothland on the Swedish side, and in the smaller isles of Dago and Oesel, near the Russian shores. Thus it would seem that

immediately after the completion of the Lower Silurian group, these two continents were elevated and placed beyond the reach of the depositary influence of the sea in which the isles were formed, and therefore that in ancient times, as at the present day, a great trough existed between these opposite continental masses of land. This early elevation was probably unaccompanied by any great fractures; for the lower Silurian rocks of both lands have still preserved a general horizontality, which is the more remarkable in the case of Russia, as it has been shown that the sediments, after having been raised, must again have been depressed to permit of copious marine accumulations of Devonian age upon their surface. In like manner, we must believe from the evidences of conformable apposition of the Devonian and carboniferous deposits of Russia, that no sort of disturbing influence could have existed in these regions when the one formation succeeded to the other. The uppermost beds of the Devonian, loaded with *Holoptychius* and *Onchus*, *Cocosteus*, *Placosteus*, and *Dendrodus*, are at once conformably surmounted by strata containing the most universally diffused carboniferous types. In short, fishes identical with those of the Old Red Sandstone of Scotland are invariably surmounted by the *Stigmaria ficoides* and the large *Producti* of our British mountain limestone; and thus the examination of Russia has taught us, not only in this instance, but also in the overlying Permian succession, that the great changes in animal life have not been dependent on physical revolutions of the surface, but are distinct creations, independent of any such proximate local causes; though I would by no means deny that the grand operations of change which have affected the conterminous regions of Russia did not tend to produce these results.

The first elevation and depression of the Lower Silurian strata having been moderate, and probably not extensive, and those strata having, during the long succeeding Devonian and carboniferous periods, remained beneath the sea, in which these sediments were accumulated, we next reach that period of disturbance which is so strongly marked in nearly every part of Europe, or that which followed the close of the carboniferous epoch. Then it was that the whole of the older palæozoic series of Northern Russia was raised up in lines extending from S. W. to N. E. And, although even then their elevation must have been infinitely more equable than any of those upheavals which have determined the strike and escarpments of rocks of the same age in Western Europe, we cannot imagine the upward movement of such enormous masses from beneath the sea to some height above it, without the accompaniment of some of those transverse fissures and breaks, which, though feeble in the slightly elevated tracts, increase in intensity with the amount of upheaval.

TABLE I.
LOWER SILURIAN FOSSILS OF SCANDINAVIA,
AS COMPARED WITH THOSE OF OTHER REGIONS.

NOTE. In this Table the Subdivisions of the Swedish Lower Silurian series are thus denoted :
A. S., Argillaceous slate ; Al. S., Alum slate ; O. L., Orthoceras limestone.

	Sweden.	Norway.	Russia.	England.	America.	Remarks.
<i>Crustacea:</i>						
Calymene bellatula Dalm. - - O. L.	+		+			
ornata Dalm. - - O. L.	+	+		+		
(Paradoxides bimucronatus Sil. Syst.)						
Fischeri Eich. - - O. L.	+	+				
sclerops Dalm. - - O. L.	+					
clavifrons Dalm. - - O. L.	+					
centrina Dalm. - - O. L.	+					
verrucosa Brong. - A. S.	+					
laciniatus Dalm. - A. S.	+					
Trinucleus Caractaci Sil. Syst. Al. S. & O. L.	+	+		+	+	
Lloydii Sil. Syst. - Al. S. & O. L.	+			+		
brevis sp. n. - Al. S. & O. L.		+				
asellus Bæck. - Al. S. & O. L.		+				
Asaphus platynotus - - A. S.	+					
? cyllarus His. (Trinucleus) A. S.	+					
raniceps Dalm. - - O. L.	+					
seticornis His. (Trinucleus) O. L.	+					
angustifrons Dalm. - - O. L.	+					
palpebrosus Dalm. - - O. L.	+					
(Symphisurus Goldf.)						
mucronatus - - O. L.	+					
extenuatus - - O. L.	+					
Buchii (dilatatus var.) - O. L.	+	+	+	+	+	
heros (tyrannus) - - O. L.	+	+	+	+	+	
expansus - - O. L.	+	+	+		+	Cryptonymus Eichwald, Hemipterurus Razumofskii Green.
_____ var. cornutus -	+		+			
Ampyx nasutus - - Al. S. & O. L.	+	+	+	+		¹ Occurs in Ireland.
Illænus crassicauda - - O. L.	+	+	+	+	+	
centrotus - - O. L.						
laticauda - - O. L.	+				+	
Olænus scarabæoides - - Al. S.	+	+		+		
(Anthes Goldf.)						
paradoxides - - Al. S.						
vesiculosus - -						
Tessini - -	+	+		+		
(Paradoxides Br.)						
Agnostus lævigatus - - Al. S.	+	+				
(Battus Dalm.)						
pisiformis Brong. - Al. S.	+	+		+		
<i>Mollusca:</i>						
Orthoceras duplex Wahl. - - O. L.	+	+	+			
vaginatus - - O. L.	+		+			
trochlearis His. - - O. L.	+	+		+		
tenuis - - O. L.	+	+		+		
centralis - - O. L.	+	+				
Lituites convolvans His. - - O. L.	+	+	+			
lituus His. - - O. L.	+	+	+			Ireland and Wales.

TABLE I. — *continued.*

	Sweden.	Norway.	Russia.	England.	America.	Remarks.
<i>Orthis pecten Dalm.</i> - - O. L.	+			+		
polygramma <i>Dalm.</i> M.S. - -	+	+		+		
caligramma <i>Dalm.</i> - - O. L.	+	+	+	+		
alternata <i>Sow.</i> - - O. L.		+		+		
virgata <i>Sow.</i> - - O. L.		+		+		
testudinaria <i>Dalm.</i> - - O. L.	+		+	+		
<i>Pentamerus oblongus</i> - Pent. L.st.	+	+		+	+	
var. borealis Pent. L.st.			+			
<i>Terebratula (Atrypa) crassicostris Dalm.</i> A.S.	+	+				Near to a Coniston species <i>Sedgwick.</i>
nucella - - -	+	+	+			
canaliculata - - - Al. S.	+	+				
<i>Lingula longissima</i> - - O. L.						
<i>Leptæna sericea</i> - - O. L.						
<i>Spirifer lynx</i> var. - - O. L.	+	+	+		+	Group of <i>S. biforatus Schlott.</i>
(<i>Atrypa dorsata Dalm.</i>)						
porambonites - - -	+	+	+			
<i>Avicula orbicularis Foralsberg.</i> -	+			+		
<i>Euomphalus Gualteriatius</i> - - O. L.	+	+	+		+	
<i>Crinoidea</i>						
<i>Sphæronites (Echinospærites) auran-</i> O. L.	+	+	+	+		¹ Occurs in Ireland.
tium.						
(Fam. Cystideæ <i>Von Buch.</i>)						
<i>Polyparia</i>						
<i>Chætetes (Favosites) petropolitanus</i> O. L.	+	+	+	+	?	
<i>Graptolites sagittarius, &c.</i> - - A. S.	+	+	+	+	+	
<i>Fucoidæ.</i>						
<i>Ceramites Hisingeri Liebmann</i> - Al. S.	+	+	+			

TABLE II.
UPPER SILURIAN FOSSILS OF SCANDINAVIA,
AS COMPARED WITH THOSE OF OTHER REGIONS.

	Sweden.	Norway.	Russia.	England.	America.	
<i>Crustacea</i>						
<i>Calymene Blumenbachii</i> - - -	+	+	+	+	+	
var. pulchella - - -	+	+	+	+		¹ Occurs in Ireland.
punctata - - -	+	+		+	+	
Downingia - - -	+		+	+	+	² Occurs in Capelhamn.
<i>Phacops macrophthalmus</i> - - -	+	+		+	+	
<i>Asaphus caudatus</i> - - -	+			+	+	
Stokesii - - -	+			+	+	
<i>Brontes flabellifer</i> ? ? - - -	+			+		
<i>Cytherina Baltica</i> - - -	+			+		Nehou, France. Tiinan Chain.
<i>Mollusca</i>						
<i>Orthoceras ibex (annulatus His.)</i> - -	+	?		+		
crassiventris <i>His.</i> - - -	+	?				
(nummularis <i>Sow.</i>) - - -	+	?				
undulatus <i>His.</i> - - -	+	?		+		
(annulatus <i>Sow.</i>) - - -	+					
tenuis - - -	+	?		+		
communis - - -	+	?		+		
imbricatus - - -	+	?		+		
<i>Gomphoceras pyriforme Sow.</i> - - -		+		+		
<i>Phragmoceras compressum Sow.</i> - - -		+		+		
<i>Terebratula marginalis Dalm.</i> - - -	+			+		
imbricata - - -	+			+		
plicatella <i>Dalm.</i> - - -	+	?		+		
Wilsoni - - -	+	+		+	+	
(lacunosa <i>His.</i>) - - -						

TABLE II.—*continued.*

	Sweden.	Norway.	Russia.	England.	America.	Remarks.
<i>Terebratula bidentata</i> <i>His.</i> - - -		+		+		¹ Occurs in Ludlow?
<i>semisulcata</i> - - -	+	+		+		
(<i>lacunosa</i> <i>Sow.</i>)						
<i>sublamellaris</i> (<i>Münster</i>) - - -		+		+ ¹		
<i>reticularis</i> - - -	+	+		+	+	
(<i>affinis</i> <i>Sow.</i>)						
<i>aspera</i> - - -	+	+		+	+	
<i>nucula</i> - - -	+			+		
<i>Atrypa tumida</i> <i>Dalm.</i> - - -	+	+		+	+	
(<i>tenuistriata</i> <i>Sil. Syst.</i>)						
<i>Pentamerus galeatus</i> - - -	+	?	+	?	+	
<i>conchidium</i> - - -	+					
(<i>Gypidia</i> <i>Dalm.</i>)						
<i>Leptæna depressa</i> - - -	+	+	+	+	+	
<i>euglypha</i> - - -	+	+	+	+	+	
<i>transversalis</i> - - -	+			+	+	
<i>Orthis</i> (near <i>rugosa</i> ?) - - -		+		+		
<i>orbicularis</i> - - -	?	?	+	+		
<i>rustica</i> - - -		+		+		
<i>Chonetes sarcinulatus</i> - - -	+			+		
(<i>Orthis striatella</i> <i>Dalm.</i>)						
<i>Spirifer radiatus</i> <i>Sow.</i> - - -	+	?		+		
(<i>Delthyris cyrtæna</i> (<i>Dalm.</i>))						
<i>ptychodes</i> <i>Dalm.</i> - - -	+	?				
<i>pisum</i> - - -		+	+	+		
<i>trapezoidalis</i> - - -	+	+		+		
<i>crucialis</i> sp. n. <i>Sow.</i> - - -		+		+		
<i>biloba</i> (<i>sinuata</i> <i>Sow.</i>) - - -	+	+		+	+	
(<i>cardiospermiformis</i> <i>His.</i>)						
<i>Cypricardia cymbæformis</i> <i>Sow.</i> - - -	+			+		
(<i>Cardium carpomorphum</i> <i>Dalm.</i>)						
<i>Mya rotundata</i> - - -	?			+	+	
<i>Lucina prisca</i> (<i>Tellina</i> sp. <i>His.</i>) - - -	+					
<i>Trochus ellipticus</i> - - -		+				
<i>Turritella obsoleta</i> - - -	?		+	+		
<i>Turbo Williamsi</i> - - -	?		+	+		
<i>Euomphalus funatus</i> - - -	+	?		+		
<i>sculptus</i> - - -		+		+		
<i>alatus</i> - - -	+	+		+		
<i>carinatus</i> <i>Sow.</i> - - -	+			+		
(<i>Inachus sulcatus</i> <i>His.</i>)						
<i>Crinoidea.</i>						
<i>Hypanthocrinus decorus</i> - - -	+			+	?	
<i>Actinocrinus moniliformis</i> - - -	+			+		
<i>Tentaculites ornatus</i> - - -	+	+		+		
<i>Caryocystites granatum</i> (<i>Cystideæ</i> <i>Von Buch</i>). - - -	+					
<i>Incert. sed.</i>						
<i>Cornulites serpularius</i> - - -		+		+		
<i>Polyparia.</i>						
<i>Catenipora escharoides</i> - - -	+	+	+	+		
<i>labyrinthica</i> - - -	+	+	+	+	+	
<i>Favosites gothlandica</i> - - -	+	+	+	+		
<i>polymorpha</i> - - -	+	+	+	+		
<i>spongites</i> - - -	+	+	+	+		
<i>alveolaris</i> - - -	+	+		+		
<i>Porites pyriformis</i> - - -	+		+	+		
<i>Cyclolites lenticulata</i> - - -	+			+		
(<i>numismalis</i> <i>Esmarck</i>)						
<i>præacuta</i> - - -	+			+		
(<i>numismalis</i> <i>Hisinger</i>)						
<i>Syringopora reticulata</i> - - -	+	+	+	+		
<i>Ptilodictya lanceolata</i> - - -	+		+	+		
<i>Stromatopora concentrica</i> - - -	+	+	+	+		
<i>Aulopora serpens</i> - - -			+	+		
<i>conglomerata</i> - - -			+	+		
<i>Cyathophyllum turbinatum</i> - - -	+		+	+		
<i>dianthus</i> - - -	+			+		
<i>ceratites</i> <i>Goldf.</i> - - -	+		+			
<i>Millepora repens</i> - - -	+			+		

II. REPORT

ON THE

CORALS FROM THE TERTIARY FORMATIONS OF NORTH AMERICA.

COLLECTED BY MR. LYELL, AND DESCRIBED BY W. LONSDALE,
ESQ., F. G. S.

I. *Account of Ten Species of POLYPARIA obtained from the Miocene Tertiary Formations of North America.*

The following is a list of the species :—

1. *Anthophyllum lineatum* *Lonsdale*. (*Caryophyllia lineata* *Conrad*.)
2. *Columnaria* (?) *sexradiata* *Lonsdale*. (sp. n.)
3. *Astrea hirtolamellata* (?) *Michelin*.
4. *Heteropora* (?) *tortilis* *Lonsdale*. (sp. n.)
5. *Escharina tumidula* *Lonsdale*. (sp. n.)
6. *Lunulites denticulata* *Conrad*.
7. *Cellepora informata* *Lonsdale*. (sp. n.)
8. *Cellepora umbilicata* *Lonsdale*. (sp. n.)
9. *Cellepora quadrangularis* *Lonsdale*. (sp. n.)
10. *Cellepora similis* *Lonsdale*. (sp. n.)

A. *Polyparia Anthozoa*.

1. ANTHOPHYLLUM LINEATUM.

Stems conical or cylindrical, short, clustered, outer surface ribbed unequally; lamellæ numerous, breadth variable, irregularly grouped, sides papillated, edges rugged; centre union of highly foraminated or reticulated lamellæ; terminal cup deep, very rugged, centre projecting papillæ; connecting laminæ thin; additional stems produced from germs on the sides or at the base of pre-existing.

Lithodendron flexuosum, Michelin? *Iconographie Zoophytologique*, p. 49. pl. 10. f. 2. *Caryophyllia lineata*, *Conrad*. MS. label.

This fossil differs essentially from any of the corals originally assigned by Schweigger to *Lithodendron**, or any of those to which the term has been applied by English palæontologists†; it differs also equally from the species of Lamarck's *Caryophyllia* to

* Beobachtungen, &c. Syt. Table VI.

† Phillips, Geol. Yorkshire, part ii. p. 202.

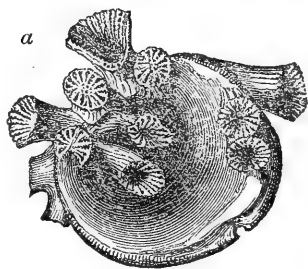
which Ehrenberg has beneficially restricted that genus* ; but it agrees with certain of Schweigger's *Anthophylla*†, in having the stems connected by intermediate layers, or those to which Ehrenberg has advantageously limited the genus.‡

A comparison of the American specimens with a fine series of a Touraine coral in Mr. Lyell's cabinet, believed to be that figured and described by M. Michelin, led to the inference, that there was no essential difference ; nevertheless it has been thought advisable to adopt Mr. Conrad's specific name, lest a student should consider the American or Touraine fossil as identical with the existing *Caryophyllia flexuosa*, one of the synonyms given in the "Iconographie Zoophytologique."

The stems were generally attached to testacea, and for the greater part were closely aggregated, the young being occasionally clustered round the sides of the older. They were frequently cylindrical, but sometimes conical, and differed considerably in the diameter of the superior termination in instances of equal altitude. The greatest height was 5 lines, and the greatest diameter of the same stem $4\frac{1}{2}$ lines. The sides of the coral, and the adjacent surfaces of the bodies to which it was attached, were coated by a thin layer of animal secretion, indicating that the mantle of the polype or its appendages invested the solid polypidom and in part the supporting body ; but free connecting layers were not so strongly developed as in many of the Touraine specimens of equal dimensions, though probably of greater age.

The young stems were essentially produced from germs, originated in the investing portions of the polype, and sprung either from the sides of the older, but without any connection with their interior, or from near the base ; and they soon attained their full diameter. One terminal cup presented irregularities not unlike those which accompany the subdivisions of *Dædalina*, but the evidence was not sufficient, when opposed by very numerous cases in which germs appeared to be the ordinary mode of reproduction, to warrant the inference that the coral was a true subdivisional polypidom.

Localities. — Petersburg, Williamsburg.



Anthophyllum lineatum. Near the base of the stem, at *a*, the free edge of an imperfect connecting plate is given. §
[Natural Size.]

* Die Corallenthiere des rothen Meeres, 1834. and Berlin Trans. 1832.

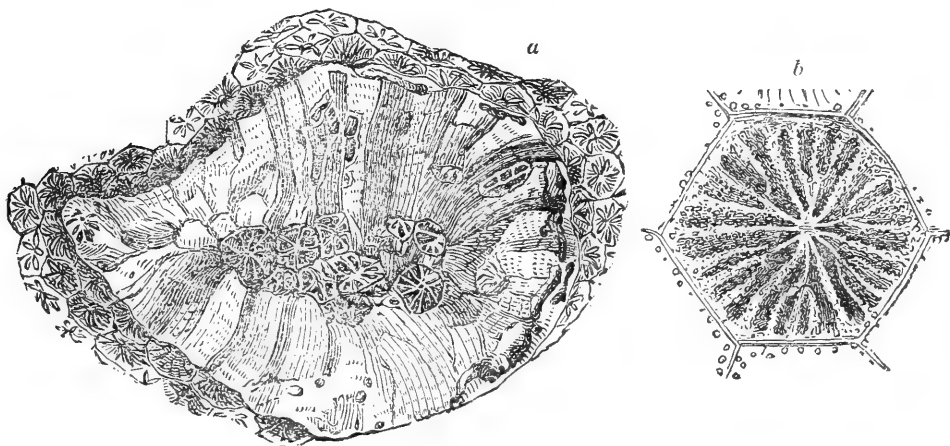
† Op. cit. Table VI.

‡ Op. cit. p. 89. Ehrenberg's characters are, "*tubuli laminis membranaceis (pallii appendicibus) laxè ferruminati, ramosi, in interstitiis (stolonibus) gemmipari.*"

§ For an analogous mode of grouping in a recent species, consult Esper's figure (Pflanzenhiere, Madrep. Tab. 28.) of Ehrenberg's *Anthophyllum fasciculare*, the *A. Esperi* of Schweigger.

2. COLUMNARIA (?) SEXRADIATA.

Polymorphous; tubes polygonal, divergent; adjacent walls separable, externally traversed by indistinct ribs and transverse inequalities; lamellæ variable in width, and simple or grouped, according to age; interstitial laminæ not numerous; terminal immature star, sides of lamellæ vertical, interspaces wide, open; terminal mature star shallow, sides of lamellæ thickened obliquely, the thickening extending across and closing the interspaces; boundary between stars a slight groove; centre of column and star a union of lamellæ; additional columns interpolated.



a. Section of *Columnaria sexradiata* of the natural size, exhibiting the tendency of the columns to separate; and in the centre, irregularities in the structure of the columns, owing to interference during development.

b. A terminal star enlarged, to show the characters believed to be connected with the final termination of growth.

This fine fossil agrees with the *COLUMNARIA* of Goldfuss in the simplicity of the internal structure, and in the mode of producing additional columns; but changes in the terminal stars, analogous to those exhibited in the coral under consideration, do not appear to have been noticed in *Col. sulcata* or the other species described by Professor Goldfuss (Petref. p. 72.). The generic determination is therefore considered doubtful. Corals possibly allied to this fossil have been figured from Maestricht by M. Goldfuss under the name of *Astrea angulosa* (Petref. pl. 23. f. 7.), and from the muschelkalk of France by M. Michelin by the name of *Ast. polygonalis* (Iconog. Zoophytol. pl. 3. f. 1.); but the American polypidom is most clearly not an *Astrea*, as limited by Ehrenberg, nor does it belong to any of that authority's allied genera, the mode of reproduction being most decidedly not by a subdivisive process.

The specimens which were examined varied considerably in form, being cylindrical, or lobed, or developed in broad expansions; yet the plan of growth was the same in every case, the columns radiating abruptly from a central line or imaginary axis, and being

of limited length. The finest specimen had a somewhat trapezoidal form, the greatest breadth being rather more than 6 inches, the greatest width $4\frac{1}{2}$, and the greatest thickness 2. The opposite surfaces were slightly uneven, but perfectly occupied by well-preserved mature stars, and the edges were slightly lobed or fractured. The greatest range of the columns was about nine lines; and the width of the terminal stars almost uniformly two lines.

In the lower portion of the most regularly formed tubes, which might be considered as representing an early condition of the coral, there were only twelve very thin slightly curved lamellæ, each formed, however, of two closely united plates, and the arched or flat union of the opposite plates constituted the outer wall. In the lower portion of tubes not regularly developed, the lamellæ varied in number, being for the greater part rudimentary, as well as in form and mode of union; but they were relatively very thick, and their biplated composition was perfectly distinct: the outer wall had also considerable dimensions; and the transverse laminæ were greatly contorted. In this portion of both regular and irregular tubes, the sides of the lamellæ and of the inner wall were vertical, and not minutely tuberculated; and the interspaces were deep and open. As the coral advanced towards maturity, the number of lamellæ increased to twenty-four, six of which were simple and rather prominent, and ranged from the periphery to the centre, while between each of these was a group composed of two converging narrow plates with a middle broad one, which extended also to the centre. In this state, the upper edges of the lamellæ and the boundary wall began to thicken, and to be coated with fine papillæ; the interspaces were also contracted, but the cup was relatively deep, with slightly tuberculated edges. In what was believed to be the final state of growth, the changes just noticed were much more marked; the six simple broad lamellæ rose distinctly above the others, the papillated layer extended across the interspaces, and had relatively considerable thickness (two lines), the depth of the cup was greatly diminished, the boundary of the stars had lost their tubercles, and the separation was almost constantly defined by a well-marked groove. In this state, no line of natural separation between the columns could be detected, the thickening being apparently persistent, and regularly developed, conforming to the structure of the stars, the characters of which were uniformly exhibited. These specimens, it should be remarked, indicated clearly that the polypes died long previous to their solid fabrics having been enveloped in mineral matter, fragments of small parasitic testacea being attached to the surface, and the exterior as well as the interior being penetrated vertically and obliquely by the vermiform cavities of some existing species of marine animal. They exhibited also the peculiar aspect displayed by existing *Anthozoa*, after the death of the animal, over the whole or a portion of a specimen.

Changes somewhat analogous, as respects the obliteration of the terminal cup, occur in a polypidom belonging to the coral rag of

Steeple Ashton* (England), and believed to be referable to the *Thamnastrea* of Lesauvage. In that fossil, however, there is no columnar structure at any period of growth, but a perfect blending of lamellæ; and there is no thickening layer. In specimens of *Porites pyriformis* obtained by Mr. Austen from the Devonian limestones of England, changes equally great with those exhibited by *Columnaria*? *sexradiata* have been noticed†; and the lamellæ-tubes of *Heliopora cærulea* (De Blainville) are at one period totally obliterated by an extension and union of the lamellæ: again, in *Pocillopora acuta* (Lamarck) the polype cavities, always shallow, are in lower portions of a specimen sometimes perfectly filled up, and occasionally difficult to detect; while in *Oculina virginea*, the tubes cease after a time to be prolonged, though the intermediate spaces continue to thicken, and finally to extend over the mouths of the tubes: lastly, another case of obliteration, unattended, as in the *Oculina*, by any marked changes in the structure of the part occupied by the body of the polype, has been noticed in a specimen of *Gemmipora crater*? (De Bl.), in which the oldest of the projecting stars were completely buried under a thickened extension of the intermediate reticulated structure. These changes, partly noticed on former occasions, are mentioned, because they are believed to be of great importance in generic, and under modified conditions in specific determinations, and because they do not appear to have claimed sufficient attention.

As respects the reproductive process, it is necessary to premise that not a single indication was observed of a subdivision in a terminal star. Cases of interpolated small or young columns were not numerous on the surface of the large flat or conical specimens, on account, it was inferred, of the sudden divergence and restricted growth of the columns having produced few interspaces; but in conical or lobed specimens, which implied continued growth, young stars were noticed, irregularly crowded between others of greater dimensions, with more or less well-defined lines of separation or partition; and along the centre of fractional sections similar proofs of interpolation were exposed.

Localities. — Evergreen, James's River, Petersburg?

3. *ASTREA HIRTOLAMELLATA* Michelin?

Stars polygonal in close contact, unequal; lamellæ numerous, alternately broad and very narrow, sides papillated, edges rugged; centre union of lamellæ; terminal cup deep, edges of lamellæ considerably curved; boundary between the stars sharp, rugged, no blending of lamellæ.

Astrea hirtolamellata Michelin? Iconographie Zoophytologique, p. 162. pl. 44. f. 5. 1845. (Parnes, Grignon, &c.)

* See Mr. Lyell's Elements of Geology, 2d edit. ii. p. 43. fig. 239.; also the *Astrea favosioïdes* of Smith's Strata Identified, Coralline Oolite, fig. 1.; and Phillips's Geol. Yorkshire, part i. p. 126. pl. 3. fig. 7. Likewise consult *Thamnastrea Lamourouxii*, Michelin's Icon. Zoophytologique, p. 109. pl. 25. fig. 3.

† Trans. Geol. Soc. of London, 2nd ser. vol. v. descrip. pl. 58. fig. 4.

The fossil referred doubtfully to *M. Michelin's* species consisted of a series of young stars attached to a *Balanus*, and therefore did not exhibit an equivalent state of development to the specimen figured by that authority; but the general resemblance between the corals was too great to justify the proposing a distinct specific name.

The American fossil presented apparently only one condition of growth, the terminal cups penetrating to the thin base-layer which coated the surface of the *Balanus*, and there was scarcely a trace of interstitial laminæ; the narrow lamellæ were also very indistinct on the lower side of the walls. The specimen nevertheless displayed different degrees of development, in consequence of the production laterally of additional stars. In the more mature stage the walls had a relatively considerable elevation, and the broad lamellæ a great regularity of character: there was, moreover, among these stars an important instance of a young one, due, it was believed, to a subdivisive process. In the less mature stage, the walls, though equally sharp on the upper edge, had much less height, and the broader lamellæ were unequally developed. The example of what was considered a subdivided star—a characteristic of Ehrenberg's restricted genus—is given near the letter (a) in the wood-cut, and it exhibits what are believed to be satisfactory proofs of its origin; the wall on one side being regularly angular, and lined with alternately broad and rudimentary lamellæ uniformly developed, while on the opposite side the wall is arched, and there are only two irregular lamellæ-plates.

Locality. — Williamsburg.

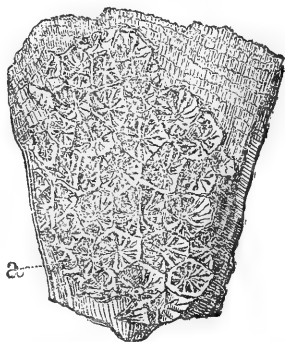
B. *Polyparia* Bryozoa.

4. HETEROPORA ? TORTILIS. (Sp. n.)

Branched; branches dichotomous, thick, short; tubes long, cylindrical or slightly compressed, sometimes in contact, sometimes slightly separated by intermediate animal secretions, divergence great; walls thin, minutely punctured, not separable mechanically; no transverse diaphragms; larger tubular openings round or slightly angular, edges sharp, no regular arrangement; smaller openings round or angular, often very numerous, occasionally few in number; additional tubes produced partly in the axis, partly in the lateral portions of the branches.

The genus HETEROPORA*, established by M. de Blainville on

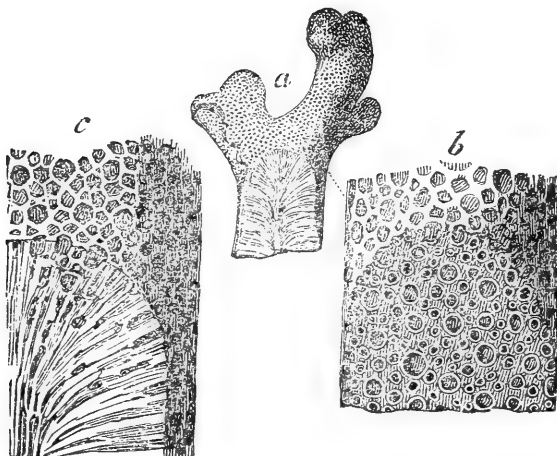
* Ehrenberg's genus *Heteropora* (Beiträge, &c. 1831—1834. and Berlin Trans. 1832.), founded on a subdivision of Lamarck's *Madrepore*, was probably proposed about the same time as De Blainville's (Man. d'Actinol. 1830—1834.), but it does not appear to have been adopted.



Astrea hirta-lamellata.

Near the point indicated by the letter (a) is an imperfect star, due apparently to a subdivisive process in the fully developed star next to it.

[Natural Size.] †



a. Heteropora tortilis. Natural size. General appearance of the coral, and mode of branching.

b. Portion of the same specimen greatly enlarged, exhibiting characters of the surface, and showing the variable size and circular form of intersected tubes, as well as the distinct walls, and the general appearance of the intermediate matter.

c. Vertical section, greatly magnified, to show the mode of radiation, and of interpolating additional tubes.

three species of Prof. Goldfuss's CERIOPORÆ, has not been described either by its founder or by other authorities with sufficient fulness to enable an opinion to be formed of its complete characters, or of the nature of the minor openings, one of the assigned essential structures; nor does Goldfuss's account of the three species afford satisfactory additional details of peculiarities of composition. An examination of his figures (Petref. pl. 10. f. 3. 5. 9.), as well as those of the two species of Lamouroux's fossil *Milleporæ* (Exp. Methodiq. pl. 82. f. 7, 8. pl. 83. f. 6, 7.), removed by M. Milne Edwards to *Heteropora* (Lamarck, 2nd edit. t. ii.) will, it is conceived, justify the conclusion that the genus consists of tubular corals; and perhaps the inference that the smaller openings are the terminations of interpolated immature tubes, in no respect analogous to the fine pores in young branches of *Myriapora truncata* (De Blainville). Should these suppositions be correct, the American fossils would agree with those figured by Goldfuss and Lamouroux to the extent inferred: still there are essential characters neither noticed nor represented by those authorities or others in describing the same fossils, as the existence or not of transverse diaphragms, the nature of the walls of the tubuli, and whether the coral underwent any changes during growth or subsequent to maturity; and without a perfect acquaintance with which, generic determinations in this division of polyarians must be always unsatisfactory. The impossibility of comparing fully the American specimens with the structure of those on which M. de Blainville established his genus *Heteropora*, required, therefore, that the assignment should be given with a doubt.

The numerical proportions between the large and small openings varied greatly, the latter occupying sometimes a considerable part of a limited surface; but an examination showed that these minor apertures were terminations of young or imperfectly developed tubuli; every condition, from a minute foramen to a large circular tube, having been observed both on the surface and in sections of the interior; and in the latter cases small tubuli, representatives of minute apertures, were noticed gradually attaining, in the range towards the surface, the dimensions of the large circular openings. No indications were detected of a subdivision within a full-grown tube by a vertical plate ranging partly or wholly across it, the mode by which additional polype cavities are chiefly produced in *Chaetetes*; but in every instance the young tubuli had been developed in spaces due to divergence, and either occupied them wholly, or were embedded in a pellucid interstitial matter. The original wall of the tubes, where preserved, presented in transverse sections an opaque white circle, strongly contrasted to the surrounding pellucid matter; and the smallest as well as the largest opening exhibited the same character; in vertical or oblique sections a similar layer was also sometimes exposed, minutely, but clearly punctured, the pores penetrating likewise into the surrounding interstitial substance. No changes dependent upon growth, or upon the cessation of it, were observed.

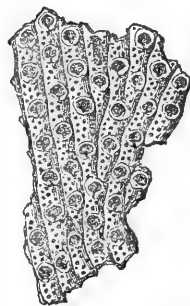
In attempting to assign a position in the natural series of *Polyparia* to the coral under consideration, it is believed that the characters of the tubuli, the want of internal diaphragms, the structure of the walls, and the mode of developing additional tubes, prove it to belong to the *Tubuliporidae* of M. Milne Edwards, or the *Tubuliporea* of M. de Blainville; and that if it be rightly assigned to *Heteropora*, the genus should be removed from M. de Blainville's family of *Millepora*.

Localities.—Williamsburg, Petersburg.

5. ESCHARINA TUMIDULA. (Sp. n.)

Cells oblong; rows radiating, divided longitudinally by a furrow, but not separable mechanically; no transverse furrow between successive cells; surface slightly convex, with well-defined, large, round pores; mouth circular, boundary slightly thickened, two small protuberances on the proximal edge, sometimes a small tooth on each side.

But one condition of growth of this species was noticed, and it is fully represented in the wood-cut. The cells were in general regularly arranged with reference to the individual rows; but there was no uniformity of disposition as respected the whole surface. Their length was about one fourth of a line, and breadth one sixth. The interpolated or additional series sprung from the side of an oral termination; but from their mode of insertion, they might be considered as having had an independent origin, or having been developed from gem-



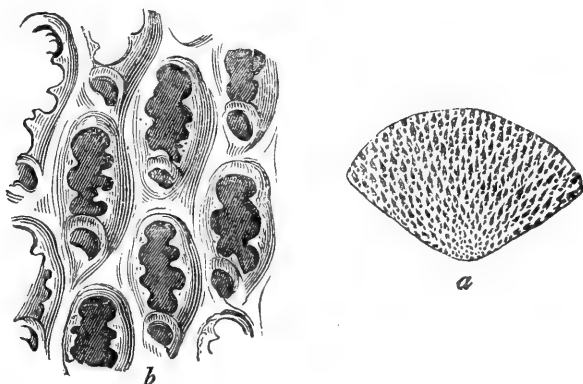
Escharina tumidula.
[Greatly magnified.]

mules. In every case, however, the first additional cell had been clearly derived from that in which the regular successive cell did not occupy the whole of the distal termination, there being, in both instances, the same want of a distinct transverse separating line, while between the interpolated and the other pre-existing rows, the regular longitudinal furrow was continued. No signs of accessory foramina or of gemmiferous (?) vesicles were noticed.

Locality. — Petersburg.

6. LUNULITES DENTICULATA Conrad.

Conical ; cells in alternate rows, oblong externally, interior conical, nearly vertical to the two surfaces of the polypidom ; immature state, exterior of cell open or denticulated on the margin, mature, covered ; mouth near distal extremity semi-circular when imperfect, circular when perfect ; gemmiferous (?) chamber at distal end of cell, opening round ; concave surface irregular, furrowed, minutely granulated, or punctured ; distance between the two surfaces variable.



a. *Lunulites denticulata*, magnified four times in linear dimensions.

b. Cells greatly enlarged to exhibit the denticulated edge of the immature state, and the characters of the chambers between the cells.

Lunulites denticulata Conrad. Silliman's Journal, Oct. 1841. (Vol. 41.).

This minute *Lunulite* is believed to belong to the species described, but not figured, by Mr. Conrad ; and for a knowledge of the notice in Silliman's Journal, I am indebted to Mr. Lyell. So far as the only specimen contained in the collection would permit a comparison to be made, it resembled greatly a *Lunulite* found in the crag of England, and possibly that identified, in the "Annals of Natural History" for January, 1844 (p. 18.), with the recent *Lun. Owenii* of the African coast (Gray's "Spicilegium Zoologicum," part i. p. 8. t. 3. f. 15. 1828.) ; but as the published notice of the latter does not afford sufficient means for determining the amount of agreement between the recent and fossil corals, it has been deemed advisable to adopt Mr. Conrad's specific name.

This *Lunulite* differed from the species described in the notice on the eocene polyparians (*postea*), in the important characters of the cells being arranged alternately, in the total absence of inter-

mediate rows of foramina, and in the occurrence at the distal extremity of each cell of a shallow circular hollow or chamber. These structural differences appear to have a constant dependence upon each other; all the quincuncial species examined by the describer having a similar chamber, and all with parallel rows having intermediate series of large foramina. Moreover, in the published figures of *Lunulites* with alternate cells, as those of *Lun. umbellata* given by M. de France (Atlas, Dic. Sc. Nat.), and copied by M. de Blainville (Man. d'Actinol. pl. 72. f. 1.), the situation of the oral aperture and of the chamber is fairly expressed in the general magnified figure, though less happily in the three separate cells (fig. a); and in the representation of *Lun. rhomboidalis* given by Goldfuss (Petref. pl. 37. f. 7.) the chambers are well delineated and have a strong boundary, but are alluded to in the description as oral apertures. M. Michelin, also, in his account of *Lun. intermedia*, a quincuncial species, says, "chaque grand pore est accompagné d'un plus petit, qui lui est inférieurement placé." (Icon. Zoophy. p. 75.) In Crag and Touraine *Lunulites* the arrangement of the cells equally influences the position of the chamber; and in the genus *Fenestella** the species with parallel cells have an intermediate row of pores or small chambers; while those with quincuncial series have a chamber analogous in position with that at the distal extremity of the cells of *Lunulites*. It has been deemed right to solicit attention to these characters, because they do not appear to have received the consideration they merit; and because the perfect analogy between the position and nature of the cavities in quincuncial species with the chambers in *Eschara* and *Escharina*, supposed to be receptacles for maturing gemmules, may assist in forming a correct opinion respecting the intermediate rows of foramina or cavities in *Lunulites* and *Fenestella*.

The specimen examined was only $2\frac{1}{2}$ lines in diameter; but it presented many different conditions of the cells. Along the irregular margin were a few round chamber-apertures, with well-defined boundaries, but the plane of the opening was oblique to that of the outer surface of the cells. Similar apertures, occupying a nearly analogous position, occurred over the whole surface of the specimen, and had preserved their characters unaltered, whatever changes the cells had undergone. This invariableness appears to be a property by which the chambers may be always readily distinguished from other structures. The cells immediately succeeding the margin exhibited large central open spaces more or less fringed by projecting points; and the development of the outer covering was apparently effected, as in other species, very irregularly, the process in some cells towards the margin being more advanced than in others farther from it. In the most matured cases, short of a perfectly continuous surface layer, a small opening was preserved near the distal extremity, not very

* See Appendix A. (vol. i.), *Fenestella*, in Mr. Murchison, M. de Verneuil, and the Count von Keyserling's work on the Geology of Russia. 1845.

regular in outline, but which might be considered, in that condition, as an oral aperture. In the perfectly closed cells, near the base of the inverted cone, a slightly concave and apparently solid lamina, occupied the whole surface. A careful study of the general characters dependent upon the mode of forming this outer layer will, it is believed, be found of service in establishing specific differences among *Lunulites*, equal to that derivable from the variable manner of producing the equivalent portion in *Escharæ* and *Escharinæ*.

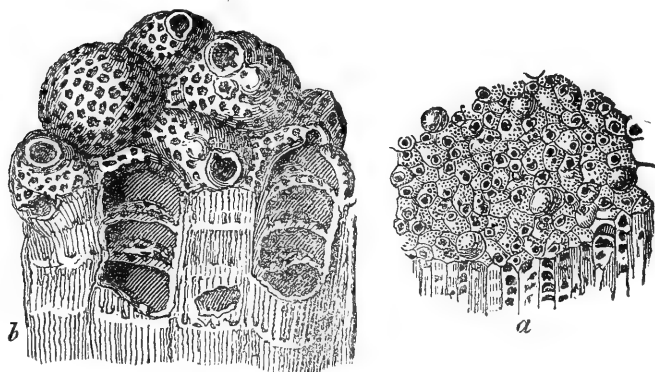
In the concave surface, the point of chief interest was the irregular thickenings, connected, it is believed, with renewals of growth, a feature of common occurrence in quincuncial species, but not yet observed by the describer in those with parallel cells, although M. Michelin has delineated carefully an apparently analogous structure in *Lun. urceolata*. (Icon. Zoophyt. pl. 46. f. 6. 1845.) Where the renewed growth was supposed to have commenced, a layer, of animal origin, extended backwards from the previous margin, and coated irregularly the anterior concave surface, but with a clear separating line. In other species, which permitted, on account of duplicate specimens, an examination to be made, the thickening layer was easily detached, and its surface was found to be impressed with the structure of that to which it had been added, and without any blending of materials; nevertheless, the layer differed not in the arrangement of its component materials (an apparently vertical fibrous or laminated structure) from that which immediately underlaid it, or was directly connected with cells, and secreted by the polypes which occupied them.

Locality. — Williamsburg.

7. CELLEPORA INFORMATA. (Sp. n.)

Incrusting, compressed globular or irregularly botryoidal cells, form variable, surface densely porous; mouth circular or oval, in same plane with surface, margin raised, thickened, at proximal edge a narrow plate notched in the centre; gemmiferous (?) chamber, on one side of proximal margin of mouth; walls of cells separable; vertically fractured section irregularly columnar; connecting foramina near base of walls.

This coral and the next were referred to *Cellepora*, on account of the irregular manner in which the cells were aggregated, and of the want of uniformity as respected the general surface of the oral terminations; in the situation of the chambers assumed to be destined for maturing the gemmules there was also an agreement, as well as in the absence of all marked changes dependent on extreme age, with *Cellepora pumicosa*, and allied recent or extinct species. Both fossils, however, presented the peculiarity of the walls of the cells readily separating, and each portion of a fractured specimen exhibited constantly flat, glossy, apparently solid walls, totally unlike the curved surfaces occasionally obtained in fractured sections of *Cell. pumicosa*: in the characters of the mouth, in its being in the same plane with the surface, however



a. Portion of *Cellepora informata* magnified four times in linear dimensions. It exhibits the irregular arrangement of the cells; the occurrence of semi-globular mouthless cells, and the columnar structure of a fractured section.

b. Cells greatly enlarged, to give the characters of the tubercle near the proximal edge of the mouth, and the position of the gemmuliferous (?) vesicle or chamber. The vertical section shows the unobliterated pores in the surface of inferior cells.

irregular the position of the cell, and in the structure of the outer covering, the resemblance to *Eschara* or *Escharina* was much greater than to the typical species of *Cellepora*; nevertheless it was deemed advisable to refer the Virginia fossils to that genus provisionally.

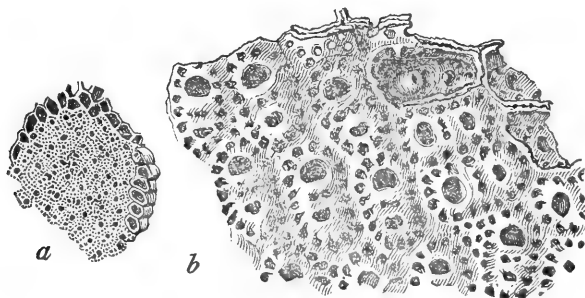
In what was considered a series of immature cells, the mode of distribution agreed with that of parasitic *Flustræ* or *Escharinæ*, the development having arisen from the distal extremity of mature cells; and several successive rows had been produced without the appearance in the first series of a decided commencement of the outer surface. Though there was no difficulty in detaching a fragment of one of the minute irregular columns, with a perfect surface on each plane, and consisting of three or four cells uniformly superimposed, as if developed successively from the underlying one, yet it is conceived that the agreement was only accidental, and that the cells were produced horizontally by means of the foramina situated near the base of the walls. No progressive stages, from the immature to the mature state, were observed; but one of the former had a very narrow porous band, which agreed completely in structure with that of the perfect outer covering. No decided proofs of changes incident upon extreme age were noticed on the general surface of the specimen; and in the cells which had been overlaid by one or more generations, the mouth was not uniformly filled up, nor were the pores always obliterated or coated over by the flooring of the superimposed cells. Examples of mouthless cells occurred both in the somewhat regular layers, and in those confusedly aggregated, the shape in the former instances being normal, but in the latter globular (see figs. *a*, *b*), or of every possible inequality of outline. The gemmuliferous (?) chamber was often wanting; and where it occurred, it was not always on the

same side of the mouth. It was small and shallow, but open, the edge being well defined and slightly thickened. The tubercle beneath the mouth was also not constantly present, consisting sometimes of a slight swelling of the porous surface, but more generally of a small solid boss (*b*).

Locality. — Petersburg, Virginia.

8. CELLEPORA UMBILICATA. (Sp. n.)

Incrusting; cells in successive enveloping layers; shape irregularly oval or pyriform; surface bounded by a row of minute foramina, centre uneven, towards the proximal extremity a large transverse foramen, near the mouth two smaller foramina, in general more or less obliterated; mouth transversely oval, slightly inclined backwards, margin scarcely raised, not thickened, walls of cells separable; vertically fractured section irregularly columnar; connecting foramina near base of wall.



a. Portion of *Cellepora umbilica* magnified four times in linear dimensions, exhibiting near the edges cells in the earliest state or without the surface covering, and also the columnar character of the cells.

b. Part greatly enlarged, to show the characters of the surface and the foramina: it gives also exposed portions of the covering of inferior cells.

In all the leading structural peculiarities this species agreed with the last, except in the slightly inclined position of the mouth; and the generic assignment must be considered only provisional; in the minor details, the differences were considerable. The mode of developing additional cells on a nearly uniform level was also the same. No decided gemmuliferous chamber was noticed, but beneath the proximal lip of the mouth a minute indentation was frequently observed; and in the same position, but chiefly in the underlying layers, a prominent tubercle; and where this structure occurred, the two smaller foramina were situated at its base. The indentation or tubercle agreed in situation with the chamber or vesicle, armed, when perfect, with a long conical process in *Cellepora pumicosa*. In general only one row of pores surrounded each outer covering, but occasionally there was an intermingling of foramina, due apparently to defective developments. In the underlying cells the mouth was often obliterated, and the central foramen much contracted or filled up, but the boundary pores generally remained open: there were, moreover, no clear indications of external thickenings dependent upon age.

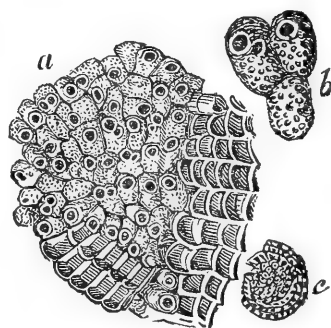
Locality. — Petersburg.

9. *CELLEPORA* QUADRANGULARIS. (Sp. n.)

Incrusting; cells disposed in concentric layers around numerous centres, no regularity respecting position of distal extremity; form quadrangular, bounded by a depressed line, surface very slightly convex, minutely foraminated; mouth not uniformly in same plane with exterior of cell, round, large, margin in general not raised or thickened, sometimes notched on the proximal edge; occasionally on one side of the mouth a large pyriform opening to a gemmuliferous (?) chamber; walls of cells not separable mechanically; vertical fracture concentrically laminated; connecting foramina near the base of the walls numerous.

This coral agreed with the two preceding in the general Eschara-like characters of the cells, in the variable position of the distal extremity, in exhibiting no changes or external thickenings dependent upon age, and in the situation of the supposed gemmuliferous vesicle or chamber; but it differed in the walls not being separable mechanically, fractured surfaces displaying almost constantly the interior of cells arranged in concentric layers, and not irregular columns detachable singly: also in the oral aperture having a less uniformly persistent position with respect to the surface plane of the cell, being in some instances terminal, and it resembled in its general characters much more nearly those of the mouth of *Cellepora pumicosa*.

This fossil attained considerable dimensions, one botryoïdal mass being $4\frac{1}{2}$ inches in width, and 3 in height; and with the exception of the small *Balani* around which it was encrusted, and a central cavity, it consisted of concentric polype-strata enveloping the botryoïdal centres. The individual layers had, however, a limited range. The cells, when unaffected by irregularities of surface, had a nearly quadrangular outline; and the mouth was in the centre of the distal extremity, if unaccompanied by the gemmuliferous (?) vesicle; but if that structure occurred, it was situated on one side. Many mouthless cells were noticed, both with and without the vesicle; but the irregularity of development which prevented the formation of the oral aperture, did not apparently interfere in any manner with the perfect conformation of the opening to the supposed reproductive chamber. Indications of the progressive mode of constructing the cells were not observed; nor, as already stated, were there any signs, either on the surface or subjacent layers, of marked changes or thickenings attendant upon age. In some cases the mouths had apparently been contracted or filled up, but



a. *Cellepora quadrangularis*: portion of an outer layer magnified, to exhibit the irregular arrangement of the cells as respects the oral termination; also near the asterisk two rows of immature cells.

b. Greatly enlarged cells, to show more fully the porous structure of the surface, and the characters of the oral apertures with the adjacent chamber; the figure includes also a mouthless cell.

c. A small section, natural size, to represent generally the concentric layers of cells.

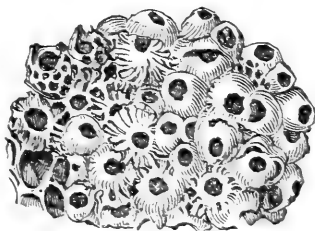
they were generally open; and obliteration of the pores, where it occurred, was probably due chiefly to the infiltration of calcareous matter. The vesicle, as shown in the woodcut, resembled, in the form of the opening, that of typical *Cellepora*, but the structure itself was more immersed in the body of the cell.

Localities.—Williamsburg, Evergreen.

10. CELLEPORA SIMILIS. (sp. n.)

Lobed or convoluted; cells globular, confusedly aggregated, surface non-foraminated, more or less traversed by reticulated or radiating ridges; mouth large, circular, terminal; a large hood-shaped projecting gemmuliferous vesicle.

This coral possessed all the leading characters of typical species of the genus, and it resembled *C. pumicosa* in the form of the cells, and in the confused mode of aggregation: in that species radiating ridges near the junction of the cells may also occasionally be detected, but to a much less extent than in the fossil under consideration. The leading distinction between the fossil and recent polyparians consisted in the perfect vesicle of the former, when exhibited in sheltered places, not having a long spinous process; and there were other minor peculiarities, as the total absence of a transverse plate near the bottom of the aperture.



Cellepora similis.

The figure represents the general characters of an outer unprotected surface greatly magnified; but the vesicle is not given in its perfect state or with the projecting hood; it exhibits accurately the radiating or reticulating ridges.

Locality.—Williamsburg.

II. Account of Twenty-six Species of POLYPARIA obtained from the Eocene Tertiary Formation of North America.

The following is a list of these corals:—

1. *Ocellaria ramosa* *Lonsdale*. (sp. n.)
2. *Flabellum*? *cuneiforme* *Lonsdale*. (*Anthophyllum cuneiforme* *Conrad*. MS. label.)
3. *Endopachys alatum* *Lonsdale*. (sp. n.)
4. *Dendrophyllia lævis* *Lonsdale*. (sp. n.)
5. *Dendrophyllia*?
6. *Cladocora* (?) *recrescens* *Lonsdale*. (sp. n.)
7. *Caryophyllia subdichotoma* *Lonsdale*. (sp. n.)
8. *Madrepora tubulata* (?) *Lonsdale*. (*Astrea tubulata* *De France*.)
9. *Porites*.
10. *Tubulipora proboscidea* (?) *Lonsdale*. (*Pustulopora proboscidea* (?) *Milne Edwards*.)
11. *Tubulipora*.

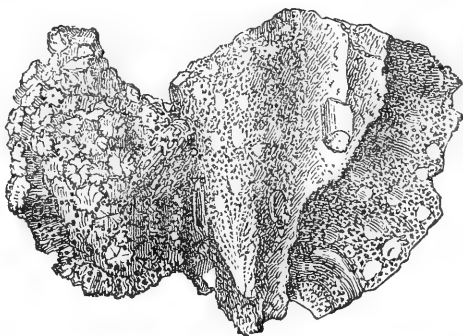
12. *Idmonea maxillaris* *Lonsdale*. (sp. n.)
13. *Idmonea commiscens* *Lonsdale*. (sp. n.)
14. *Idmonea*.
15. *Lichenopora*.
16. *Farcimia*.
17. *Vincularia*.
18. *Hippothoa tuberculum* *Lonsdale*. (sp. n.)
19. *Eschara tubulata* *Lonsdale*. (sp. n.)
20. *Eschara petiolus* *Lonsdale*. (sp. n.)
21. *Eschara incumbens* *Lonsdale*. (sp. n.)
22. *Eschara linea* *Lonsdale*. (sp. n.)
23. *Eschara viminea* *Lonsdale*. (sp. n.)
24. *Lunulites sexangula* *Lonsdale*. (sp. n.)
25. *Lunulites distans* *Lonsdale*. (sp. n.)
26. *Lunulites contigua* *Lonsdale*. (sp. n.)

A. *Polyparia Amorphozoa*.

1. *OCELLARIA RAMOSA* *Lonsdale*. (sp. n.)

Branched or lobed; fibres coarse, cylindrical or compressed, intimately reticulated; interfibril lacunæ equal in dimensions to the fibres; canals numerous, vertical in centre of specimen, horizontal towards the exterior, no definite arrangement, form more or less circular, no distinct wall, lower extremity blended with the fibrous structure, interior sometimes penetrated by converging simple fibres; exterior of specimen partially invested by a thin rugose layer.

The resemblance between the Pyrenean and Artois fossils, on which M. Ramond established his genus *OCELLARIA**, and those bodies which Dr. Mantell designated in the first instance *Alcyonium chonoides*†, and subsequently *Ventriculites*‡, was, it is believed, originally pointed out by Mr. Conybeare§; and Dr. Mantell has identified the *V. alcyonides*|| with M. Ramond's *Ocellariæ*. To what extent this generic agreement may be accepted, the descriptions in the work on Mont-Perdu do not af-



The right of the figure represents a concave cast of the exterior of *Ocellaria ramosa* of the natural size, with portions near the bottom of the surface crust minutely punctured; the centre of the figure is a conical branch composed entirely of canals with intermediate reticulations; and the left is a series of transverse sections of canals, exhibiting a smooth surface irregularly intersected by fissures, which indicate the extension, originally, of fibres.

* Voy. au Mont-Perdu, p. 345. pl. 2. f. 1, 2. 1801, but previously described in No. 47. of Bull. Soc. Philom.

† Linn. Trans. vol. xi. p. 401. *et seq.* 1814—1815.

‡ Geol. of Sussex, p. 176. *et seq.* 1822.

§ Outlines Geol. Engl. p. 76. 1822.

|| Trans. Geol. Soc. London, 2d series, vol. iii. p. 205. 1828—1829.

ford the requisite information for determining ; but it is believed that M. Ramond may have associated with his *O. nuda*, obtained in the Pyrenees, the *O. inclusa* from Artois, without a full consideration of all the structural characters, or on a mere resemblance in the nature of the canals and the fibral tissue. How far this supposition, and the conjecture that *O. nuda* does not belong to *Ventriculites*, may be correct, an examination of specimens only can decide. In attempting, however, to ascertain the nature of certain American fossils, and the most nearly allied known genus, it was found that essential differences existed between those remains and *V. alcyonoïdes* as well as *V. radiatus* ; while so far as M. Ramond's figures of *Ocellaria nuda*, particularly (1 *b.*), could be relied on, a considerable agreement was apparent ; and it has therefore been deemed advisable to consider the Mont-Perdu fossil as distinct from *Ventriculites*, and to associate generically with it these fossils from America.

Ocellaria ramosa consisted apparently of a fibrous body not divisible, as in *Ventriculites*, into layers of different composition, and penetrated by irregularly arranged canals — also of a partially developed, thin, investing, non-fibrous crust. Neither the solid casts representing the inter-fibral lacunæ, nor those which occupied the canals exhibited in the fossil any signs of contraction : there was also a total want in the calcareous matrix of all indications of a thick, gelatinous, coriaceous, or other covering. The canals sprung apparently from the axis of the specimens, and after ranging for some distance more or less vertically, diverged outwards in every direction, the plane of the opening coinciding with that of the surface. At the lower extremity they blended with the fibral structure ; and it is believed that they were, to a certain extent at least, progressively obliterated. In other portions of their range they were often penetrated irregularly by simple fibres, and sometimes in a manner which gave the transverse section a star-like or radiated aspect. Mr. C. B. Rose, of Swaffham, has pointed out a similar appearance in *Ventriculites*.* In transversely fractured specimens, the calcareous matter, which occupied the canals, presented generally a smooth but irregularly impressed surface, which had been clearly moulded on a soft or yielding material ; and in more than one instance proofs were obtained of two successive similar surfaces at distances exceeding a line, and their position was shown by a cross fissure or narrow interval, due to the removal of the original body. In some cases the canals were few in number or distant ; but in one specimen they were so numerous as to occupy nearly the whole of it, the interspaces being limited to a single series of very short fibres or merely connecting processes, without the least signs of contractions. The partially developed outer crust presented its greatest thickness and persistence near the base of the specimen, where it completely concealed the fibres and canals ; but in other places its extent was limited,

* Loudon's Mag. Nat. Hist. vol. ii. p. 335. fig. 93 *b.* 1828—1829.

and it had been pierced by single projecting fibres as well as by the terminations of the canals. Independent of the prominent transverse rugosities, subordinate lines parallel to them were noticed in some of the thicker crusts.

Localities.—Jacksonboro', Georgia ; Eutaw, South Carolina.

B. *Polyparia Anthozoa.*

2. FLABELLUM? CUNEIFORME. (sp. n.)

Conical, compressed ; pedicle small, cylindrical, lateral processes few, minute ; lamellæ numerous, united centrally in lower portion of the cone, sides finely tuberculated ; terminal cup deep, lined by lamellæ of variable breadth, not united in the centre, upper edges convex ; outer wall thin, smooth externally, minutely foraminated.

This fossil, named in MS. by Mr. Conrad *Anthophyllum cuneiforme*, was removed from the genus noticed on the MS. label, because it differed essentially in structure from the corals to which it is conceived *Anthophyllum* should be restricted (*antê*, p. 496.) In considering it as a *Flabellum*, the describer has been guided by the resemblance to the polypidoms assigned to that genus by M. Michelin (Icon. Zooph. pl. 9. f. 11—14.) ; but the determination is given doubtfully on account of M. Milne Edwards considering the *Diploctenium* of Goldfuss as identical with the *Flabellum* of Lesson (Lamk. Anim. sans vert. 2d ed. vol. ii. p. 364.) ; because the describer had not the power of comparing the Maestricht and recent corals with each other, or with the American fossil ; and because the stated characteristic of *Flabellum*, a division of lamellæ in the centre ("la ligne médiane est vide," Icon. Zooph. p. 44.), is either wanting in the fossil under consideration and others allied to it, or confined to what may be called the region of the terminal cup.* It is nevertheless evident that M. Michelin has rendered good service in removing from *Turbinolia* the polypidoms referred by him to *Flabellum*, and having thus disturbed the regular transmission of determinations not well-considered. A clear, restricted, definition of *Turbinolia*, and a right assignment to other genera of many of the species included among them, has long been wanted. Ehrenberg, by establishing *Desmophyllum*, *Cyathina*, and *Monomyces*, made an excellent beginning, and to them may be transferred some at least of the attached polyparians which have been regarded as *Turbinolia*, and single unbranched *Caryophyllia* ; while a careful study of the recent *Ilanthus* or mud *Actinia*† of Prof. E. Forbes will, it is conceived, lead to a right understanding and separation of the turbinated corals found in schistose strata, originally muddy, which exhibit no proofs of terminal or lateral attachment. Pallas, in de-

* Consult the following figures referred to by M. Michelin in his descriptions of *F. avicula* and *F. cuneatum*, Goldf. Petref. pl. 37. f. 17. Parkinson, Org. Rem. ii. pl. 4. fig. 9. Beiträge, or Berlin Trans. 1832.

† Annals Nat. Hist. vol. v. p. 184. pl. 3. 1840.

scribing *Madrepora trochiformis*, or the *M. simplex turbinata* of Fougé, a well-known Gothland coral of similar characters, says that it perhaps lived in sand.* These remarks are submitted to the reader's attention, because some free or sharply terminated corals exhibit signs of not having been permanently invested by the polype.

Only casts of the terminal cup and of portions of the exterior of *F. ? cuneiforme* were examined.† The chord of the arched or upper extremity of the interior of the cup was in some cases nearly an inch, and the inferior parallel breadth and the greatest depth were both five lines. These dimensions, it is conceived, would leave for the lower part of the cone, or that in which the lamellæ were centrally united, a depth of five lines. The lamellæ as well as the other portions of the original coral were wholly removed; but from the curved impressions on the casts of the interspaces in the terminal cup there had evidently been no union of the lamellæ along the central line, but an open narrow space, while the base of the casts uniformly exhibited as clear proofs of a perfect blending or reticulated structure. The lamellæ which lined the cup were shown by the same means to have been of unequal breadth, and to have had finely tuberculated surfaces. The thinness of the original wall was proved by the narrow interval between the casts of the cup and of the exterior, and its foraminated structure by numerous filiform processes which traversed about half the interval.

M. P. Gervais identifies *Flabellum pavoninum* (Lesson), with *Turbinolia rubra* (Guoy et Guimard)‡, but he affords no additional information respecting the earlier habits of the polype. Whether the American fossil was at any time wholly enclosed in the animal, the specimens afforded no means for determining; but there can be no doubt that it, as well as others believed to be generically identical with it, was not only attached by the base, but received additional support, during one period of growth at least, from lateral appendages developed sometimes slightly, sometimes to a considerable extent. These processes, which often exhibit sharp, fractured edges, were evidently formed by secretions transmitted through the minute channels visible in them, and connected with the interior structure; while their variable dimensions, as well as unequal distribution in different species, depended apparently upon the form and wants of the animal, or the degree of irritation arising from its having occupied a sheltered or exposed position. Their existence, it is believed, necessarily leads to the conclusion that the exterior was not, during a certain portion of the polype's life, covered by a soft persistent mantle conforming in shape to the outline of the coral; nor does it appear that any of the fossil

* Elenchus, German translation, pl. 2. p. 59. 1787. Consult also Dr. Fleming's notice of *Fungia turbinata*. Wern. Mem. vol. ii. p. 250.

† It has been found necessary to omit figures of these which had been prepared.

‡ "C'est le même animal que le *Turbinolia rubra*." Sup. Dec. Sc. Nat. t. i. p. 484.

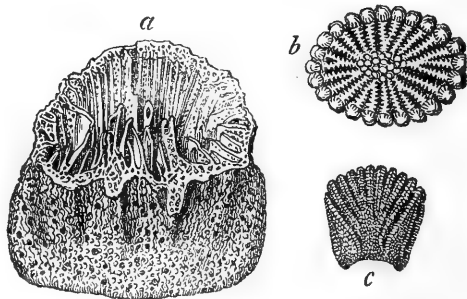
bodies furnished with them were so thickened on the outer surface that the processes became partially or wholly overlaid. These characters are considered deserving of attention, as they may assist, conjointly with other structures, in determining how far polyparians, at one period fixed and at another free, are capable of being generically united.

Localities.—Eutaw; Wilmington; Cave Hall.

3. ENDOPACHYS ALATUM.

Wedge-shaped, expanded at the base, irregularly ribbed; about twelve prominent, broad, simple lamellæ, intermediate lamellæ numerous, of variable breadth, grouped, sides minutely tuberculated; outer surface in the lower part almost wholly occupied by small papillæ, with few intermediate foramina; in middle region, openings more numerous, in uppermost papillæ few, structure reticulated; ribs formed of similar structure; thickening towards the base considerable, traversed throughout by the foramina.

Two Alabama eocene corals exhibited characters which demanded special attention. One specimen represented by figure *a*, and believed to be generically allied to the other delineated (fig. *b. c.*) resembled closely the *Turbinolia semigranosa* of M. Michelin (Icon. Zoophy. pl. 43. f. 2. 1845.); and it is with fossils usually assigned to that genus that the American coral must be compared. In both the small and larger specimens there was a total want of a pedicle, or of a cicatrised detached surface—the sharp, wedge-shaped lower termination of the former being slightly concave, and beset with minute points, while the same extremity of the large specimens, though thin, was rounded, and uniformly coated with the small tubercles which covered the general outer surface (see fig. *c.*). To this extent, therefore, a perfect agreement existed with *T. crispa*, *T. sulcata*, and *T. mixta*, but the resemblance proceeded no further. In those species, recognised types of the genus, the external surface was not modified or thickened by secretions either from within or without; whereas the Alabama coral was progressively altered in aspect by the development of tubercles secreted through foramina connected with the internal structure. Again, in the *Turbinolia* above mentioned, the lamellæ preserved great simplicity of arrangement under all conditions, while in the American coral they were exceedingly complex in the full-grown state, varying greatly in breadth, and united in groups: still farther, the boundary in *Turbinolia crispa*, *sulcata*, and *mixta*, is also very simple, consist-



a. Mature specimen of *Endopachys alatum* fractured in the upper part. (Mag. $1\frac{1}{2}$, linear.)

b. Upper termination (Mag. twice, linear) of a small coral belonging to the genus;

c. A side view of the same specimen magnified rather less than twice.

ing of a vertical layer traversed by the outer extension of the lamellæ, and it is not visibly foraminated; but in the Alabama fossil the boundary is highly perforated, as well as the portions of the lamellæ immediately adjacent, the whole composing a reticulated almost spongy structure. This aggregate of differences marked, it was conceived, something more than a specific distinction from the typical *Turbinolia* with which the comparison was made.

In extending the inquiry to other fossils for the purpose of ascertaining if similar essential structures could be detected under modified conditions, it was found that they were all combined in that manner in *Turbinolia elliptica*, with the addition, however, of clear proofs in different specimens, that this coral was at one time fixed, but at another free. How far the habits of species may render necessary a prolonged or brief attachment, or even one of so short duration that a very minute individual would be necessary to afford signs of a once fixed base, no information has been obtained; but it is conceived that the want of such a character in the Alabama coral cannot be regarded as more than a minor specific distinction.

No lateral processes adapted to afford additional support were noticed in either of the fossils, nor any impediments to the exterior having been perfectly enclosed by the polype, the plan of producing the uniform thickening not being incompatible with such an envelopment; nevertheless, no indications of it were observed beyond the absence of parasites and of interruptions to the uniform production of the papillæ.

In the characters of the lamellæ, the manner of their blending with the outer wall, and the general nature of the exterior, these polypidoms agreed with the *Dendrophyllia* of M. De Blainville; while the mode of growth was perfectly dissimilar. This union in the same coral of the habits of Ehrenberg's *Fungina* with the structures of some of his *Ocellina*, families belonging to distinct orders in that author's classification, is considered of sufficient importance to deserve the reader's attention being directed to it.

Believing that the Alabama coral (fig. *a*), the species called *Turbinolia elliptica*, and probably *T. semigranosa*, have a unity of composition and more than specific distinctions from *T. crispa*, *T. sulcata*, and *T. mixta*, it is proposed to consider them as the basis of a new genus, for which the term ENDOPACHYS* was suggested by Mr. Lyell, and the following characters are proposed:—

A stony lamelliferous coral, single, conical or wedge-shaped, fixed in the earlier stages of growth, free in the older; lamellæ numerous, variable in character, grouped, highly foraminated near the centre and periphery; no transverse diaphragms; middle a union of broader lamellæ, with a transverse reticulation; boundary wall greatly foraminated, so blended with the lamellæ as to form at the junction a reticulated structure, progressively thickened by papillæ secreted from within; detached base gradually overlaid by papillæ similar to those of the general surface.

* Ενδον, within; παχυσ, thick: in allusion to the thickening from within.

The smaller specimen (fig. *c.*) will be found to resemble greatly *T. semigranosa* (Icon. Zooph. pl. 43. f. 2.), differing, however, slightly in its outline, and more markedly in the external sculpturing, and in the surface being covered to a greater extent by papillæ. The characters of the lamellæ in the French fossil are not given, but in the Alabama specimen (fig. *b.*), they were of nearly equal breadth, partially grouped, and densely covered by sharp tubercles projecting far across the interspaces; between the lamellæ and the external ribs was in general a slight furrow. These characters differ greatly from those represented in figure *a*; and as it was impossible to ascertain by sections the young condition of that fossil, it was considered advisable to figure the smaller specimen without venturing to determine its precise nature.

Concerning the larger coral (fig. *a.*) no additional remarks appear requisite; but it may be stated, that the papillæ strongly resemble those which coat the under side of *Fungia agariciformis*; and that in the light porous stone of Stoudenmire Creek (South Carolina), casts occur, possibly derived from an analogous body, though they have greatly the aspect of impressions from a sponge.

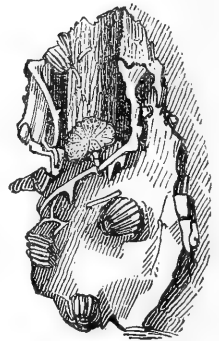
Localities. — Alabama; Stoudenmire Creek?

4. DENDROPHYLLIA LÆVIS. (sp. n.)

Branches with a persistent, central, lamelliferous structure, and many lateral shoots scarcely projecting beyond the thickened surface of the stems; lamellæ numerous, unequal, about ten principal plates in the side shoots; cast of the outer surface generally smooth, sometimes finely ribbed in young branches, or near the extremity of the shoots.

This fossil resembled *Oculina* in the mode of branching, and in the numerous lateral shoots scarcely extending above the surface of the main stem; but in none of Lamarck's or De Blainville's typical species of that genus does a master star or lamelliferous column range continuously throughout the centre of the branches. Ehrenberg unites *Oculina* with *Dendrophyllia*, but De Blainville was apparently justified, on account of the structure just noticed, in making a marked distinction. In the side shoots scarcely projecting above the surface, the American coral resembles *Dendrophyllia digitalis* (De Blainv.), found in the tertiary deposits of Touraine, but in all other particulars the differences are very great. (Consult M. Michelin's excellent figure, Icon. Zooph. pl. x. f. 10.; also Guettard's Mém. t. iii. p. 512. pl. 53. f. 8.)

In the specimens of the coral which were examined, the whole of the original substance had been removed, and even casts of the central structure were partially wanting. The most illustrative portion is represented in the woodcut. Of the nature of the thickened matter in which the lateral shoots were originally im-



In the upper part of the figure (Mag. twice, lin.) is represented a portion of a main stem of *Dendrophyllia lævis*, with a side branch structurally disconnected from it; also casts of burrowing parasites; and in the lower a cast of the exterior of the coral with portions of side branches.

bedded, no opinion could be formed, except that it was probably very solid or similar to that of *Oculinæ*, there being no vestiges of casts of capillary tubes or of a reticulated structure, though abundant proofs of the matter having been penetrated by burrowing animals. The signs of lamellæ in transverse sections of the central part were very faint, but sufficient to show that the broadest were twelve in number, and that the intermediate ones varied from one to four. The surface of this inner cast was slightly traversed by lines indicating the vertical range of the broadest lamellæ, and by traces of irregularly disposed striæ. Between the cast and the base of the side-shoots was an extremely narrow space, proving that there was originally no structural interblending of lamellæ in the offset and main stem. The shoots at the inferior termination were obliquely conical, but they soon attained their full dimensions, so far as could be inferred from the specimens, the greatest diameter being about $\frac{1}{10}$ of an inch, or $\frac{2}{3}$ that of the central cast — a disproportion observable in recent *Dendrophyllia*. Their range was limited also to less than a line. The general outer surface was apparently smooth, but uneven as in some *Oculinæ*; and the cast of it bore traces of parasitic *Bryozoa*, an additional indication to that of the numerous burrowing animals that the polypes had perished some time previously to the specimen being enclosed in its matrix.

Localities. — Wilmington; Shell Bluff.

5. DENDROPHYLLIA?

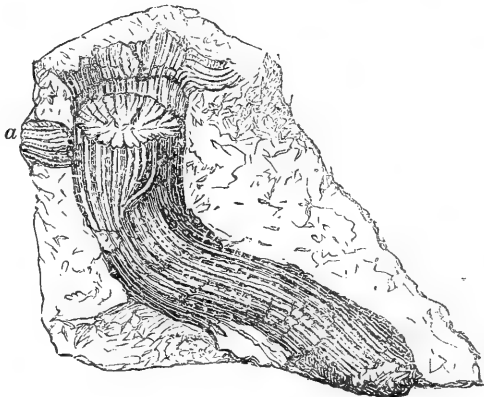
Several worn casts, possibly fragments of a *Dendrophyllia*, claimed a notice, though their generic determination could not be ascertained. They were slightly conical or cylindrical, the lower termination not unfrequently preserved, presenting the same character as that of the lateral shoots of *Dendrophyllia lævis*. The specimens had a nearly uniform diameter of half an inch at the upper extremity; and the greatest length was about an inch. The characters of the lamellæ, so far as they could be ascertained, agreed with those of *Dendrophyllia*, and in the reticulated structure of the very partially preserved exterior, as well as in the mode of union with the lamellæ, there were still further agreements. In these particulars, a resemblance also with the Alabama coral *Endopachys alatum* existed, but in no instance was a trace of a pedicle detected, nor any indication of a surface which had once been attached.

Localities. — Mulberry, Cooper River; Eutaw.

6. CLADOCORA? RECRESSENS. (sp. n.)

Branched; branches variously disposed, nearly cylindrical; outer wall thin, not thickened externally when old, porous, strongly but irregularly ribbed, and marked by lines indicative of renewals of growth; lamellæ numerous, unequal, sides foraminated and hispid; interstitial laminæ or diaphragms distant; centre a complicated reticulation; branches produced from germs developed without the area, or on the side of pre-existing stems.

This fossil agrees in many essential points, as in the amount of connection between the branches and the offsets, in the characters of the lamellæ, and in the total absence of external thickening, with the *Madrepora ramea*, var. of Esper (Pflanzenzithiere, tab. 10.), which has been referred by Lamarck to *Caryophyllia**, by De Blainville to *Dendrophyllia*†, and by Ehrenberg, but with a doubt, to *Cladocora*.‡ With respect to these generic assignments it may be stated, that believing Ehrenberg's definition of each of the genera to be the best, Esper's



A specimen of *Cladocora* (?) *recrescens* of the natural size. At *a* the characters of the side branch clearly prove that it did not originate in a subdivisional process. Indications of renewed growth are exhibited in the transverse lines on the cast of the exterior.

coral or its fossil analogue cannot be regarded as a *Caryophyllia*, on account of the branches being due to the development of germs, and not to a structural subdivision of the polype; nor as a *Dendrophyllia*, on account of the total absence of external thickenings. With respect to *Cladocora*, it can only be said, that a comparison of a specimen of Esper's coral with the American fossil proved an agreement in the principal characters; but as Ehrenberg doubted his generic determination that of the fossil is similarly marked. The peculiarity in the renewal of growth sufficiently indicates specific differences in the two polypidoms.

The specimens of *C.?* *recrescens*, which were examined, consisted wholly of casts either of the exterior or of the internal structure, but sufficient was indicated to enable the original composition to be inferred. The coral probably attained considerable dimensions, as the fragments were numerous and some portions of stems were half an inch in diameter. The thickness of the outer wall was universally inconsiderable, being represented by an exceedingly slight interval (see figure). The proofs of its having been perforated consisted in numerous thread-like processes which crossed that narrow interspace, and thickly studded also the rounded edges of the casts of the intervals between the lamellæ. The external ribs or furrows impressed upon the matrix, were likewise occasionally indented with small conical pits, due to tubercles on the original coral. The foramina in the sides of the lamellæ were represented by similar filiform processes; and the hispid projections on the surface by indentations in the casts of the interspaces between the lamellæ. The transverse lamina or diaphragms

* Animaux sans Vertebres, 2d edit. ii. p. 353. No. 10. *Caryophyllia cornigera*.

† Manuel d'Actinologie, p. 354. *Dendrophyllia cornigera*.

‡ Die Corallenthier der rothen Meeres, p. 85. *Cladocora* ? *Anthophyllum*; or Berlin Transactions, 1832.

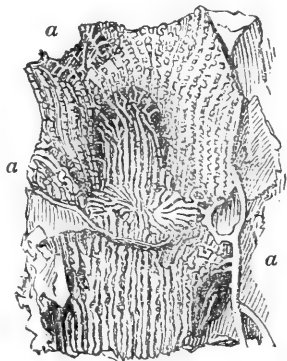
were represented by curved smooth casts nearly on the same level around the stem, in some cases, but in others unequally distributed. The supposed indications of renewals of growth consisted of sharp furrows (*a*) generally inclined downwards and outwards; and they were sometimes nearly on the same range around the casts, but they were often disposed obliquely; and they occurred at very irregular intervals. The side branches diverged most frequently at considerable angles, and without any approach to symmetry of arrangement. They were not formed in the slightest degree of pre-existing structures, the component parts of the parent stem being continued persistently upwards; and there was the same amount of interval between the base of the offset and the cast of the interior of the stem, as between the latter and the ordinary surrounding matrix. The interval was also traversed by filiform processes. There was, however, in general, more or less of irregularity at the point of issue, but without the slightest tendency to such an amount of structural blending, as would authorise the inference that the branch was a subdivisional offset from the parent.

Localities. — Jacksonboro'; Eutaw, South Carolina.

7. CARYOPHYLLIA SUBDICHOTOMA. (sp. n.)

Main stem cylindrical; branches numerous, short, slender, very divergent; outer wall thin, porous, surface finely ribbed and furrowed; lamellæ numerous, unequal, very irregular near the periphery; centre union of lamellæ; branches produced by subdivision of pre-existing structures.

The specimen preserved in the collection under consideration was of such limited extent that the characters of this coral could be ascertained but very partially. The fossil, however, clearly belonged to the family *Dædalina* of Ehrenberg, the branches arising from a subdivision of previously existing structures; and of established genera it was most nearly allied to the *Caryophyllia* of that authority.* There were nevertheless, as stated below, peculiarities in the characters of the branches, and in



The lower half represents part of a main stem of *Caryophyllia subdichotoma*, and from the transversely fractured surface near the centre of the figure, springs a branch composed partly of prolongations of the structures constituting the main stem; portions of other branches are shown near *a*. The upper half exhibits a concave cast of the exterior of the coral. (Mag. twice, linear.)

* The *Caryophyllia* of Ehrenberg is considered by that authority to be equivalent to the *Lobophyllia* of De Blainville, and the two generic names were probably proposed about the same time (1831?). It has, however, been thought advisable to retain the use of the term *Caryophyllia* as restricted by Ehrenberg, because it includes certain of Lamarck's original species, characterised by the important feature of the branches arising from a perfect subdivisional process, and because the *Caryophyllia* of De Blainville, though also restricted, includes recent and fossil corals of very heterogeneous natures, referable, for the greater part, to other well-distinguished genera.

the structure of the lamellæ near the circumference, which indicated something more than specific differences from figured Caryophylliæ, and apparently demanded the suggesting of a new genus. It was, however, deemed right not to venture so far, on the limited amount of information supplied by the specimen, but to leave to other better provided observers, who could determine the full characters of the coral, the assigning a proper generic appellation.

The single specimen, a cast, was about an inch in height and four lines in diameter, and consisted of a cylindrical stem (partially removed in the figure) with portions of three branches. The main stem had been composed of numerous lamellæ, partly united in the centre without any distinct structure, and greatly subdivided or reticulated near the circumference. The original wall was apparently very thin except at the divergence of the branches, and its general porous structure was proved by transverse filiform processes, or their fractured extremities on the ridges representing external furrows. The cast of the outer surface exhibited also other signs of minute foramina and reticulations. The branches were essentially composed, at their commencement, of certain of the lamellæ of the parent stem, including in the principal example given in the figure some of those which composed the central portion of the latter. The branches, however, differed from those of true Caryophylliæ in being of limited dimensions, and not effecting a bifurcation; also in diverging laterally and suddenly, and in permitting the main stem to be continued perpendicularly upwards. In this respect there was an agreement with the *Dendrophyllia* of De Blainville; but in that genus, the branches are not composed of previously existing lamellæ, being developed from germs. The amount of extension outwards of the branches was not shown.

Locality. — Shell Bluff.

8. MADREPORA TUBULATA?

Branched; branches irregularly divergent, cylindrical, slender, composed chiefly of long, lamelliferous tubes, springing from the centre, and diverging slightly; intermediate structure foraminated; no continuous central tube; lamellæ twelve, six very narrow, and limited in vertical range; surface terminations of tubes small, irregularly distant; interspaces echinated.

Astrea tubulata De France? Dic. Sc. Nat. t. 42. p. 384.
Astroïte tubulaire Guettard's Mémoires, t. iii. p. 511. pl. 53. f. 1—3. (Normandy between Melleraut and Mortagne, also Lisieux.)

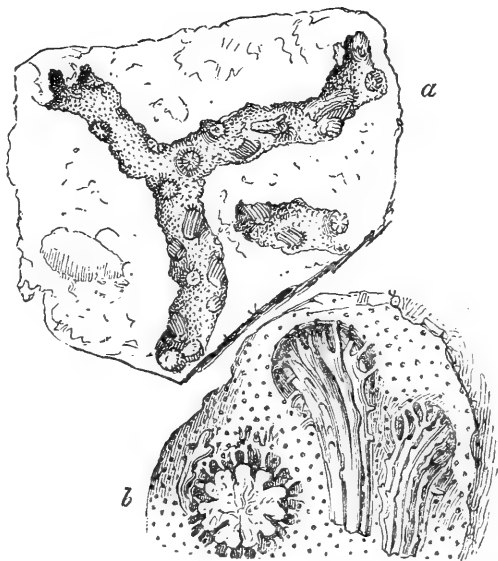
The resemblance of the American fossil to Guettard's figures was considerable, and the description of the latter, so far as it extends, agreed with the structure of the former; but the details are not sufficiently ample to warrant the conclusion that the fossils are specifically identical. The general structure of the coral, the limitation of the lamellæ to 12, and the mode of producing additional tubes or stars, rendered the removal from the

genus *Astrea* necessary; while in all these particulars, the agreement with the *Madrepora* of Lamarck (*Heteropora* of Ehrenberg) appeared to authorise the altered assignment.

The remains of *Madrepora tubulata*? consisted wholly of casts of the exterior and of the lamellæ tubes. The diameter of the branches in no case exceeded three lines, or that of the unmagnified figure (a). The tubes sprang successively from the axis and wholly composed it, to the perfect exclusion of a central, continuous tube or star. As they gradually diverged, they separated, slightly increasing in diameter;

and near the surface termination they suddenly bent outwards, their relatively great length (three lines), and small width producing the scattered distribution of the terminal stars. In Guettard's figures, the branches have a greater diameter, and the casts of the stars are closer. The lamellæ through a considerable portion of the tubes were apparently confined to the six broader, the casts of the six narrow commencing about one third from the upper extremity: both series had evidently consisted of solid plates, and not of interrupted ones as in *Porites*. So far as could be ascertained, there was no distinct, central structure. The nature of the interspaces between the tubes was very imperfectly exhibited, the remains being limited to a few filiform processes, extending from the casts of the tubes to the exterior; but the original structure constituted a considerable portion of the branches near the surface, and the lamellæ tubes were completely imbedded in it from the points of separation. The surface casts of the branches were closely and finely punctured, the indentations being surrounded frequently by a circle; and near the terminations of the tubes were, in some cases, casts of short ribs. The production of additional lamellæ tubes was apparently confined to the centre.

Locality. — Jacksonboro'.



a. Concave cast, natural size, of *Madrepora tubulata*, exhibiting the irregular distribution and convergence downwards of the lamelliferous tubes.

b. Portion of another specimen, magnified six times, linear, to give the characters of the tubular casts and of the indented cast of the exterior of the branch.

9. PORITES.

Only the casts of a few terminal stars of this coral were examined; and they did not permit a comparison with published tertiary species or the establishment of definite characters. The casts showed that the stars were slightly concave, and in close contact with a perfect structural blending at the lines of junction; and that the number of interrupted lamellæ, in the best-defined cases, did not exceed twelve.

Locality. — Jacksonboro', Georgia.

C. *Polyparia Bryozoa.*

10. TUBULIPORA PROBOSCIDEA ?

Tubes united in vertical fasciculi or branches, openings irregularly disposed, more or less prominent, no marginal thickening; outer layer investing the fasciculi smooth or transversely rugose.

An Pustulopora proboscidea? Milne Edwards, Ann. Sc. Nat. 2nd series, Zool., tome 9. pl. 12. f. 2.; also Recherches sur les Polypes, Mém. sur les Crisies, &c. (Recent; Mediterranean.)

This fossil resembled, in its mode of growth and general structure, the Mediterranean coral referred by Dr. Milne Edwards to *Pustulopora*, on account of the tubes being grouped in vertical fasciculi. It has, however, been deemed right to consider the Rock's Bridge fossil a *Tubulipora*, partly because M. Edwards has shown the close connection between the recent polypidom and that genus; and partly because a coral of common occurrence in deep water on the south-western Cornish coast, and believed to be that described by Mr. Couch, in his valuable "Essay on the Zoophytes of Cornwall," under the name of *Tubulipora deflexa*, combines, occasionally at least, an horizontal or attached with a vertically fasciculated mode of growth, the tubular openings diverging from all sides of the fasciculus. (Ninth Rep. Roy. Cornwall Polytechnic Soc. p. 72., 1841.)

Between the American fossil and Mediterranean coral, no distinction could be detected, so far as a comparison could be made, sufficient to justify a decidedly specific separation; nevertheless, as the entire habits of growth of the two polypidoms could not be ascertained, the specific determination of the fossil specimens must be regarded as very doubtful.

Locality. — Rock's Bridge.



Tubulipora proboscidea.
(Natural size and magnified.)

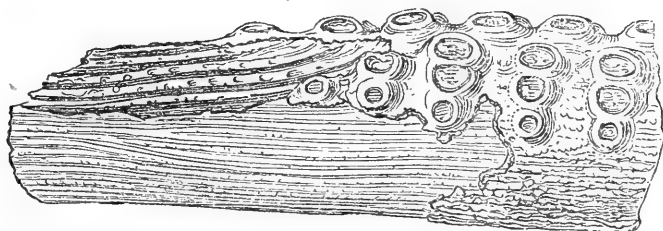
11. TUBULIPORA.

A single imperfectly preserved specimen of a *Tubulipora*, possessing characters analogous to those of Lamouroux's *Obelia*, was noticed on a shell imbedded in the white limestone of Eutaw. It was wholly attached, and consisted of three unequal lobes, which sprung from narrow bands composed of two rows of tubes each, and the bands diverged from a central point. The two larger lobes subdivided at the further extremity, and the surface of all three was occupied by abraded tubular openings, which exhibited a slight tendency to a diverging transverse lineal arrangement. In a genus of so great irregularity of growth these characters were not considered sufficient to justify a specific assignment of the specimen.

Locality. — Eutaw.

12. IDMONEA MAXILLARIS. (sp. n.)

Branches forked, oval, thickness considerable; rows of tubular openings short, alternate, mouths in contact; no central dividing ridge; tubuli very long; reverse surface semi-oval, traversed by longitudinal lines, connected by minute cross lines.



This figure of *Idmonea maxillaris* is so drawn as to represent, not the peculiar feature which suggested the specific name, but the more important characters of the tubular openings, the medial longitudinal groove between the rows, and the great range of the tubes within the branch, exposed in the upper fractured part where the openings are wanting: the figure gives also the striæ exhibited on the surface and beneath the thin outer layer.

Viewed in front, this coral resembled a Maestricht fossil, considered by Goldfuss as a young condition of *Idmonea gradata* (Petref. Corrigenda, p. 244. *Retepora disticha*, p. 29. tab. 9. f. 15. a, b), but it differed essentially from mature specimens of that species, and from Goldfuss's figures, just cited, in the plan of bifurcation, as well as in the great length of the tubes and the form of the branches. From Lamouroux's typical species (*I. triquetra*, Exp. Methodiq. p. 80. tab. 79. f. 13—15.), and some tertiary species of similar form, it was conspicuously distinguished, not merely by the rounded outline of the reverse side, but also by its great thickness.

The bifurcations occurred at irregular distances, sometimes equalling $3\frac{1}{2}$ lines, and without any prominent precursory increase

in width ; the branches also exhibited nearly their full dimensions from the very points of divergence, springing upwards after a short curve almost vertically. The portion occupied by the tubular openings formed but a small part of the circumference of the branch ; and when a fragment was placed horizontally and sideways with the rows of apertures upwards, the latter bore some resemblance to a series of teeth in a maxillary bone. The mouths were generally limited to three in each row, the outermost being the smallest. The great range of the tubuli explained apparently the considerable dimensions of the reverse portion, the interior of the branches consisting almost wholly of tubes, of one character, but decreasing in size from front to back. The uniform semi-oval outline of this portion would apparently indicate that the branches were free, or not affected during growth by pressure : nevertheless, a triangular shape does not, it is presumed, necessarily imply an attached reversed surface, M. Milne Edwards's figure of *I. radians* having a decided broad pedicle, though the branches have "la forme de prismes à trois plans" (Recherch. sur les Polyp., Mém. sur les Crisies, &c. p. 25. pl. 12. f. 4.). M. Milne Edwards was, however, fully justified in making the inference that *I. triquetra*, on account of its slightly concave reverse surface, was probably attached to the stem of a marine plant, there being in the fine collection of oolitic polyparia in the cabinet of Mr. Walton, of Bath (England), a specimen believed to be referable to that species, attached dorsally to a Terebratula obtained from the Bradford clay. It is scarcely necessary to remark, that species of other genera of Tubuliporidæ are affixed indifferently to fuci, testacea, or pebbles.

The whole of the reverse surface exhibited white longitudinal lines, with interspaces much less in width than the diameter of the tubuli. Their true nature was not ascertained, but it was believed that they were not the walls of capillary tubes, similar to those which constitute the reverse side of old specimens of *Hornera*, as they occasionally united, and the interspaces were crossed by irregular filaments. No exterior thickening or change dependent upon age was noticed ; and a fixed dorsal surface seen in some species, would prevent, it is presumed, all marked alterations on that side, as it is difficult to conceive that polypes generically identical could possess in certain species a complicated series of vessels requisite for developing a considerable additional surface, and want it in others.

Locality. — Wantoot, South Carolina.

13. IDMONEA COMMISCENS. (sp. n.)

Branches forked, triangular ; rows of tubular opening extended nearly to the dorsal surface ; no medial ridge or furrow, but an intermingling of mouths ; range of tubuli limited ; reverse or dorsal surface irregular in outline.

In the triangular form of the branches this fossil resembled the

tertiary species found at Hautville and Grignon, and figured as well as described by De France or by Milne Edwards under the names of *Idmonea gradata* and *I. coronopus* (De F., Atlas Dic. Sc. Nat. pl. 46. f. 5.; Milne Edw., Recher. sur les Polyp., Mém. sur les Crisie, &c. pp. 24. 23. pl. 12. f. 3.): but it differed in the central blending of the tubular openings; in this character there was a certain amount of agreement with the recent species of Dr. Milne Edwards, *I. transversa* (sp. cit. pl. 9. and 3.), but in the mode of branching, and form of the branches, marked differences were presented.

The reverse surface indicated apparently the irregular effects of extraneous agency, and not an uniformity of contour, as in the preceding species. In some fragments the flattening was complete, but the surface was unevenly impressed; in others, though the triangular form was retained, the reverse side was slightly convex, and in one case partly flat, partly rounded.

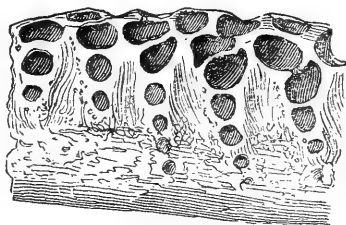
Locality.—Rock's Bridge.

14. IDMONEA.

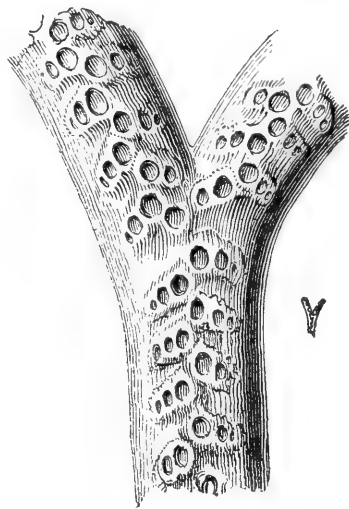
Branches divergent, rounded on the reverse side; rows of tubular openings alternate, projecting, no uniform central blending; no medial ridge or furrow; reverse or dorsal side equal half the thickness of the branch.

The fragments which afforded the above characters were found in the same specimens of friable stone as *Idmonea commiscens*. They amounted to fifteen in number, and exhibited a great general agreement in the rounding and thickness of the reverse side; but some variations occurred in the distribution of the rows of tubular openings. It was, therefore, considered advisable to give the above imperfect notice and a figure, without venturing to assign the fragments definitely either to *I. commiscens* or a distinct species. It remains also to be ascertained what amount of differences might be produced in the characters of a species by one portion of a specimen being fixed and another free.

Locality.—Rock's Bridge.



This figure of *Idmonea commiscens*, drawn on a greatly enlarged scale, exhibits accurately the central blending of the openings and the great range of the transverse rows, extending nearly to the dorsal surface.



View of *Idmonea*, of the natural size and greatly magnified.

15. LICHENOPORA.

The imperfectly preserved coral assigned to this genus was less than three lines in diameter, and was attached, except at the slightly reflected margin, to a bivalve imbedded in the white limestone of Eutaw. The surface was convex, and traversed by irregular radiating rows of tubular openings. The intermediate or non-projecting tubular openings were detectable in some places between the ridges as well as in the centre; and a weathered portion displayed a congeries of tubuli of much less diameter than those with projecting mouths.

The coral resembled a *Lichenopora* of common occurrence at Dinant and other Touraine localities, but the state of preservation did not admit of a careful comparison.

Locality. — Eutaw.

16. FARCIMIA.*

Of this coral, only the lower part of an internode, less than a line in length, and half a line in diameter, was observed. The greatest number of consecutive cells was six, and of alternate rows ten. The whole of the cells appeared to be immature, the surface exhibiting large oval openings without a distinct mouth, and bounded by a narrow band sloping downwards from the outer margins of the cells. The foramen or chamber in which it is believed gemmules are matured, was distinct and placed as in *Farcimia salicornia*, as well as in Crag and Touraine species between the consecutive cells.

The condition and nature of the specimen did not permit a comparison with other known *Farcimiæ*.

Locality. — Rock's Bridge, Eutaw, in South Carolina.

17. VINCULARIA.

Four sided, slightly bent or straight; opposite cells similarly situated; boundaries of cells oval, surface with a narrow depression in the centre, mouth semi-circular at the distal extremity of the depression.

Seven fragments of this coral, the largest about a line in length, and including four successive cells, supplied the materials for the above imperfect notice. The characters will be found to agree generally with those of *Vincularia fragilis* of De France and De Blainville (Dic. Sc. Nat. Atlas, and Man. d'Actinol. pl. 67. f. 3.; *Glaucanome tetragona* Münster and Goldfuss, Petref. tab. 36. f. 7.);

* Dr. Fleming's *Farcimia* is of posterior date to Cuvier's *Salicornia* or *Salicornaria*, but the latter name had been applied, long before, to a well-known genus of plants.

but as the figures given by these authorities differ greatly from that more recently published by M. Michelin (Icon. Zoophy. pl. 46. f. 21.), unaccompanied, however, it is to be regretted, by the descriptive details which would have removed all difficulties, the compiler of these notices refrains from assigning any specific appellation to the American coral. The chief distinction between De France or Goldfuss's figures and the specimens under consideration, consisted in the narrowness of the central depression, a character probably due to changes incident upon age. In one not very satisfactory case, the cavity was apparently filled up, a minute puncture without any raised margin indicating the position of the mouth.

Locality.—Rock's Bridge.

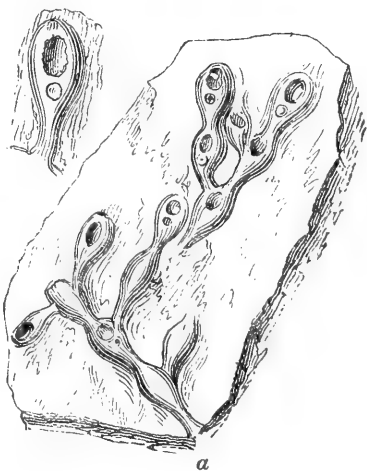
18. HIPPOTHOA TUBERCULUM. (sp. n.)

Cells pear-shaped, variously arranged; connecting tubuli generally short or wanting, rarely long; membranous aperture large, oval; solid surface or walls smooth, convex; a minute tubercle near proximal extremity of aperture.

In the form of the cells, and the characters of the membranous opening this fossil resembled greatly the recent *Hippothoa catenularia* of Dr. Fleming (Brit. Anim. p. 534.); but in numerous specimens of that coral obtained on the coasts of Devon and Cornwall, a minute tubercle near the aperture was in no instance detected. In two cases this projection was replaced, probably on account of abrasion, by an equally small cavity.

With respect to the large opening covered in the recent state, as mentioned by Dr. Johnstone, with a membrane (Brit. Zoophytes, p. 265.), cases were observed in the American fossil of what appeared to be a partial and even a total obliteration (see fig. *a*); and in a specimen of *Hip. catenularia*, the membrane in a few instances had been so thickened as to have become white and opaque.

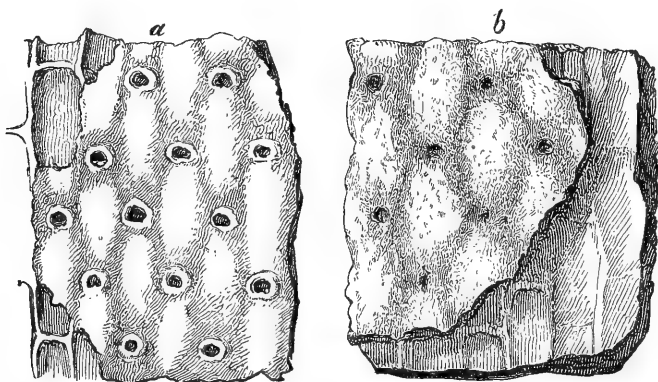
Locality.—Rock's Bridge.



This figure of *Hippothoa tuberculum* exhibits (greatly enlarged) the general mode of growth, and the tubercle or cavity at the proximal end of the oval aperture. At *a* are cells with the surface wholly covered.

19. *ESCHARA TUBULATA*. (sp. n.)

Foliaceous ; cells elongated, rows defined by a slight furrow, no marked separation between successive cells, surface slightly convex ; mouth small, transversely oval, margin thickened ; interior of cells, sides nearly straight ; dorsal separation of opposite layers imperfect.



- a.* Mature cells of *Eschara tubulata*.
b. Aged cells, the fractured portion exhibits imperfectly separated dorsal surfaces. (Magnified 12, linear.)

The above characters were obtained from a specimen an inch in length and nine lines in width, but which gave only more aged conditions of the coral. The cells in their narrow, lengthened form resembled the tubuli of *Diastopora* ; but the mouths were strictly in the plane of the outer surface, and there was not the slightest tendency to a free portion at the distal termination, or to an underlying at the proximal ; the whole outer structure being on one level, and the back of the interior parallel to it. No clear indications of vesicles were noticed. In the most aged cells, occupying the lower portion of the specimen, the exterior was lozenge-shaped, or had an increased breadth, the longitudinal furrows were almost obliterated by the thickening of the surface, and the mouths were generally very much contracted and in some cases filled up. Every attempt to separate the dorsal surfaces in this and two following species failed.

Locality. — Wilmington.

20. *ESCHARA PETIOLUS*. (sp. n.)

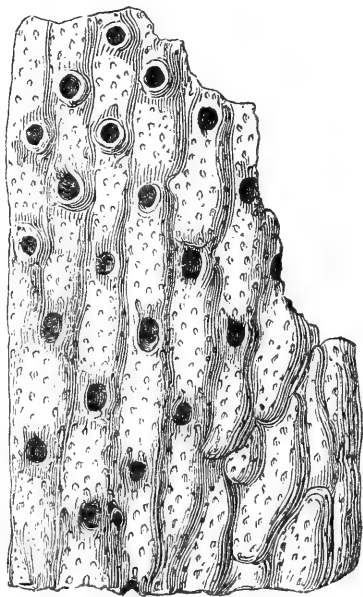
Foliaceous, springing from a stalk-like base ; cells oblong, surface slightly convex, porous, bounded by a faint furrow, mouth longitudinally oval ; sometimes a small triangular pit by its side ; interior of cells lozenge-shaped ; dorsal surfaces not separable ; connecting foramina near the base of the lateral and terminal walls.

No immature cells were observed, but in the youngest state exhibited, the mouth had a projecting margin which gradually

disappeared in more advanced conditions; while in still older, the aperture was depressed, and in the most aged totally obliterated (see figure). Other changes, dependent upon age, consisted in the diminution in number and distinctness of the pores, and in the increased convexity of the surface, with a corresponding greater depth in the separating furrows. An exposed dorsal surface was traversed by fractured edges of the walls.

In the accompanying figure (which is magnified seventeen times in linear dimensions) the greater portion represents mature cells, and the right lower part aged cells, with obliterated mouths and nearly closed foramina.

Locality. — Eutaw.

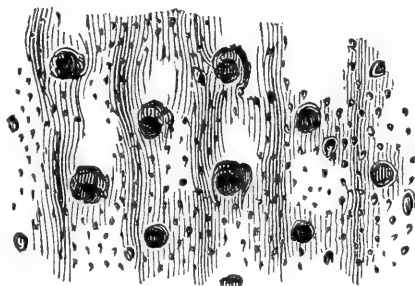


21. *ESCHARA INCUMBENS*. (sp. n.)

Foliaceous; cells oval, surface slightly convex, porous, boundary a very faint furrow, mouth round or transversely oval, notched in mature state, and margin slightly thickened; a round foramen sometimes on one side of mouth; interior of cells, lateral walls slightly curved, terminal arched or nearly straight; dorsal surfaces not separable; gemmuliferous (?) vesicle large, semi-globular, resting on next succeeding cell; connecting foramina near the base of side and terminal walls.

In addition to the aggregate of differential characters, this species is distinguished by the large overlying gemmuliferous (?) vesicle. From the mode of blending with the surface on which it rests, this chamber might be mistaken for an irregularly developed cell; but its true nature was shown by the absence of distinct pores in the lamina forming the outer covering, by the great size and inclined position of the opening, and by the true mouth of the cell, being detectable within the chamber, in its right position. In the oldest observed condition of the coral, the outer surface was greatly thickened, and the mouth of the cells was partially or wholly obliterated.

Locality. — Rock's Bridge.



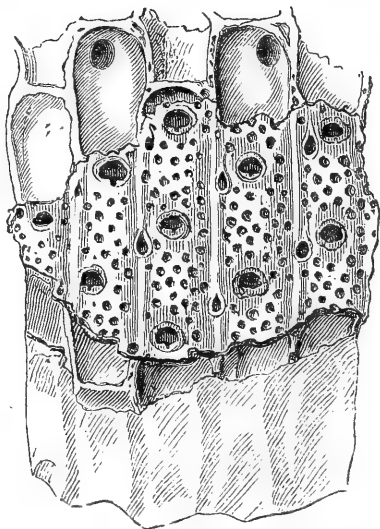
The figure represents the general characters of the surface of *Eschara incumbens*, magnified sixteen times, linear. The unforaminated portions express the chambers alluded to in the description; and the shaded part above the mouth of the cell the entrance to the chambers, the edges of the covering being, in these instances, more or less removed by abrasion, and the mouth of the cell exposed.

22. *ESCHARA LINEA*. (sp. n.)

Foliaceous ; cells oval or oblong, sometimes bounded incompletely by a slightly raised line ; surface nearly flat, very porous ; mouth transversely semi-oval, margin thickened, notched or plain on the proximal edge ; occasionally a foramen on one side of the mouth penetrating obliquely or towards a corresponding chamber at the distal angle of the interior of the cell ; dorsal separation perfect, surface ridged or flat.

The above characters were only obtained from older conditions of the coral. The raised lines were in portions of the specimens prominently developed, but in others were entirely wanting. In some cells so connected with the general surface as to indicate that they belonged to the species, the covering was much less porous, and in a few instances smooth or solid, while the mouth and adjacent vesicles, occasionally two in number, were much more prominent. These variations had been apparently produced by curvatures in the growth of the specimen. The pores differed in size and form, sometimes assuming the character of distinct, round foramina. No connection was traced between the obliquely penetrated vesicle and the small chamber at the angle of the cell ; but occasionally a distinct arched solid layer ranged from the opening of the vesicle to the distal angle of the cell. The characters of the perfectly separated, flat, dorsal surface are indicated in the figure.

Locality. — Eutaw.



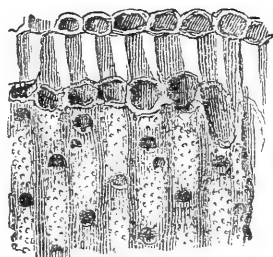
The centre of the figure represents mature cells of *Eschara linea* magnified 20, linear ; the upper part abraded cells, with indications of the pits at the angles noticed in the description, and oval foramina : the faintly-tinted lowest portion represents a perfectly separated dorsal surface.

23. *ESCHARA VIMINEA*. (sp. n.)

Foliaceous ; cells elongated, surface convex, porous, mouth transversely oval, depressed, proximal edge a notched plate ; occasionally one or two foraminated vesicles at the corners of the proximal margin ; dorsal separation perfect, surface ridged.

This species was distinguished by the wicker-like character of the general surface. Mouthless cells were noticed among those in a mature condition. The aged state presented a greatly thickened outer surface, the boundary of the cell being defined by a deep continuous groove ; the oral apertures were also obliterated and the pores rendered indistinct.

The accompanying figure represents a specimen of *Eschara viminea*, considerably magnified. In the upper part are shown a perfectly separated dorsal surface formed of angular ridges, and an inter-section of the cells belonging to the same layer: in the lower part is exhibited a series of mature cells.



Locality. — Eutaw.

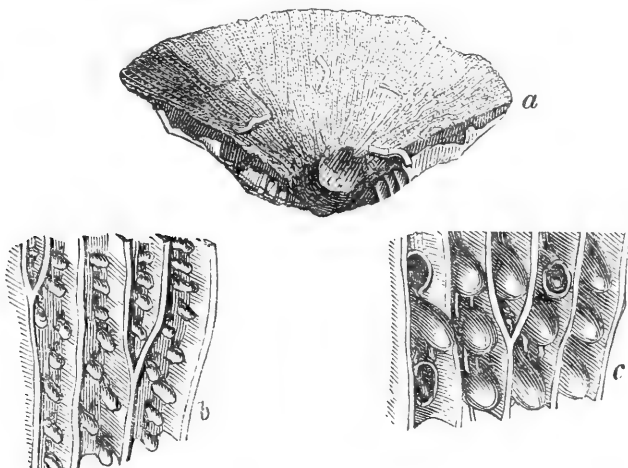
24. LUNULITES SEXANGULA. (sp. n.)

Obtusely conical; cells hexagonal in alternate rows, surface covered, raised near the distal extremity, depressed in the centre, a hemispherical tubercle frequently at the proximal end; mouth nearly central, transverse, very narrow; casts of interior of the cells hexagonal, parallel to the convex and concave surfaces; concave surface casts of irregularly radiating punctured ridges and narrow furrows, the ridges traversed more or less regularly by a row of tubercles; interval between the convex and concave surface equal depth of cells.

Locality. — Wilmington.

25. LUNULITES DISTANS. (sp. n.)

Conical; casts of cells cylindrical, short, rounded at the lower extremity, oblique to the surfaces of the cone, arranged in rows radiating from the centre and divided by thin plates; opening of cells oval; two or more foramina connecting successive cells, and several on the projecting portion; inner or concave surface broadly ribbed, foraminated; distance between the convex and concave surfaces much greater than the depth of the layer of cells, and traversed by minute channels, or tubuli.



a. Cast of the concave surface of *Lunulites distans* magnified twice, linear. The irregularity at the base represents the pebble to which the specimen was originally attached; fractured portions of the dividing plates, exceeding nevertheless the depth of the rows of cells, are given near the irregularity.

b. Portion greatly enlarged, to show the detached character and almost lineal distribution of the filaments or casts of tubuli connecting the concave surface with the cells.

c. Exhibits, greatly enlarged, the considerable oval openings of the cells on the convex surface, together with casts of the cells of the connecting foramina, and likewise the dividing plates.

This fossil resembles, in the arrangement of the cells and the form of the opening, *Lunulites radiata* and *L. urceolata* as figured by Goldfuss (Petref. 12. f. 6 and 7.), but it differs from these species in its great relative size, and, so far as its state of preservation would permit of a comparison, in many of its structural details.

The specimens consisted almost wholly of casts of the interior of the cells, of the intermediate radiating plates, representing apparently grooves between the rows of cells, casts of the minute connecting channels, and impressions of the concave surface. The diameter of one of the larger specimens was 11 lines, and the depth of the cone, in the original, was probably .5 lines; but different specimens varied considerably in the relative measurements. Some fragments presented also great irregularities along the lines of renewed growth; and casts of vermiform as well as elliptical perforations (containing in one case a minute lithodamous shell) frequently occurred in the space between the layer of cellular casts and the concave surface. The only specimen of the convex exterior which was examined was greatly worn, but it exhibited oval openings equal in dimensions to the area of the cells; and in some fragments, where casts of the cells had been removed, the same want of an exterior covering was exposed (fig. c.). In this respect *L. distans* agreed with other species, having the cells similarly arranged in radiating, non-alternate rows. Professor Goldfuss, however, states that the middle cells of *L. radiata* were closed, but he does not allude to a distinct oral aperture in the covering — a character which has been noticed in one specimen of a *Lunulites* with similarly arranged cells; and which is often strongly exhibited in species with alternate rows.* The filiform processes representing the foramina which connected the cells (fig. c.), ranged, in consequence of the partially overlying position of the casts, from the upper side of one to the under side of the next, when the specimen was placed with the apex downwards, and they differed not in character from the other processes or casts of minute channels which passed from the uncovered projecting part of the cell to the concave surface (fig. b, c.). Similar filaments extended laterally to the dividing plates. In general, the separating laminæ were much broken, but in some cases they ranged continuously between the two surfaces of the specimen. The additional rows of cells were irregularly interpolated on the lines of the dividing plates. No very clear signs of intermediate chambers, or shallow circular cavities, between the rows of cells were exhibited; but on the fragment which gave imperfectly the convex surface, faint indications were detected of depressions similar to those exhibited by Goldfuss in plate 12. figures 6 and 7 of the Petrefacta German., and by other authorities who have

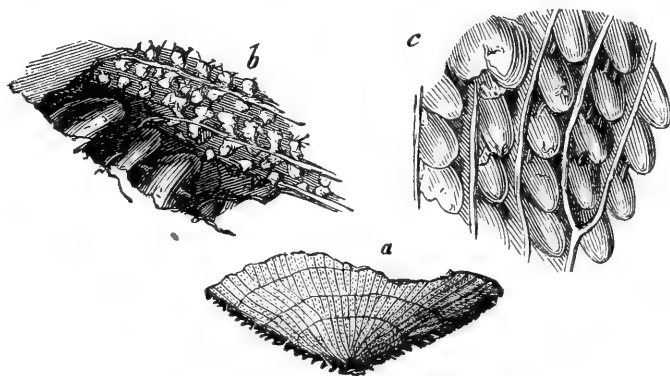
* Consult figures of *Lunulites umbellata*, &c., referred to in the notice on the Miocene *Lunulites*, *antè*, p. 504.

delineated *Lunulites* with parallel non-alternate rows.* The characters of the concave surface could not be fully ascertained, but no signs were noticed of irregular thickenings from the margin or lines of renewed growth towards the centre.

Localities. — Wilmington, Wantoot?

26. LUNULITES CONTIGUA. (sp. n.)

Conical; casts of cells cylindrical, short, oblique to the surface, opening round, rows parallel, not alternate, divided by thin plates, successive cells connected by foramina; concave surface broadly ribbed, closely indented; distance between the two surfaces slightly exceeding depth of layer of cells; a series of shallow chambers between the rows of cells.



a. Cast of the concave surface of *Lunulites contigua* magnified twice, linear.

b. Portion of the same, greatly enlarged, to exhibit the irregular nature and blending of the indentations on the surface: also the small interval between the rounded ends of the casts of the cells and the concave surface.

c. Exhibits, greatly enlarged, the lineal arrangement of the cells, the connecting filaments or casts of foramina, and the separating plates.

This species resembled the last in the characters of the cells, the connecting foramina, and the radiating plates; but it differed in the distance between the surfaces slightly exceeding the range of the cells, and in the ribs of the concave cast being densely covered by minute points sometimes blended together; no filaments similar to those which project from the equivalent portion of *Lunulites distans* were noticed.

Casts only of the interior structures, as in the preceding species, were noticed, and the characters they exhibited are fully given in the wood-cuts.

Locality. — Wilmington.

July, 1844—Sept. 1845.

* For an observation respecting these chambers see the notice on the miocene species, *antè*.

III. TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

- I. *On the Lines of ANCIENT LEVEL of the Sea in FINMARK.*
By M. A. BRAVAIS, Member of the Scientific Commission of the North.

(From *Voyages de la Commission Scientifique du Nord, &c.*)

THE general question of elevation as bearing on Geology has been one of the most important subjects of discussion in geological science in modern times, and is connected with grave consideration concerning the actual physical condition of our globe. Documents sufficiently exact with regard to the extent of a district now undergoing changes of level, and the alteration effected by each successive movement, thus become of great value, and are likely to be extremely useful hereafter in unveiling the causes of these phenomena, which indeed are even more obscure than the phenomena themselves. Now it will readily be seen what is the nature of the difficulties which almost necessarily prevent our obtaining accurate results in such cases. If the change of level is effected very slowly, as in the Gulf of Bothnia and the Bay of Puzzuoli, this slowness of the movement is itself a reason why it is impossible to arrive at any solution of the question, except after the lapse of a long series of years. On the other hand, with regard to sudden elevations, of which the extent is more limited, and the cause of which seems to have reference to direct volcanic influence, the few exact hypsometrical data we possess at present concerning the form of the earth's crust, are hardly sufficient to justify geologists in extending their researches beyond the shore, or even in tracing in the interior of a continent the effect of an elevating force. The rarity of these phenomena again, and their being generally quite unexpected, are additional obstacles in this kind of investigation.

In passing from the recent period to one a little more ancient, it may seem at first that the difficulties necessarily increase, and that, without having first determined the changes at present going on, it would be hopeless to endeavour to throw any light on those of former times. This is not however exactly the case, for an elevated coast line often exhibits numerous marks of the action of water upon it, in the shape of alluvial masses of sand and gravel, and occasionally of clay containing the remains of shells, and each

of these marks may serve as an inferior limit, assisting us in fixing the ancient level of the sea.

Besides this also the study of former elevations enables us to extend our researches over a considerable extent of the earth's surface, and multiply our observations in every favourable spot.

In addition to the deposits just alluded to, the sea has also sometimes left traces of its former presence on the shore, which, if they cannot be called more certain, are at least more precise; and not unfrequently the ancient beach is at a certain distance inland from the present one, and is indicated by the most incontestable marks. To follow one of these ancient lines of level for a considerable distance, to convince oneself at every interruption of the former continuity of the different fragments which now form the only visible mark, to prove whether the line we thus re-construct is or is not horizontal — this is a course of proceeding by which we may hope to make out the amount of disturbance that has taken place in one direction, viz. along the line of the sea-coast. If, however, the coast is deeply intersected by long and narrow bays, or if it is separated from the open sea by a number of detached islands, we are enabled by similar measurements to obtain additional data, and discover also the amount of elevation in the direction of a line at right angles with the coast line. From such combined series of data we may expect to deduce probable conclusions concerning the law which governs these disturbances and elevations of the earth's crust.

Of all countries there is none of which the coast is better adapted for investigations of this kind than Norway, and by a fortunate coincidence there is no country which offers more distinct marks of alteration of level than this. Professor Keilhau, of Christiania, has collected the observations of all his predecessors on this subject*, and combining them with his own researches has made the fact of this change of level perfectly clear. It thus appears that not only a narrow strip of coast, but the whole of Norway, from Cape Lindesnæs to Cape North, and beyond that as far as the fortress of Vardhuus, has been in course of elevation during a period immediately anterior to the historic period. On the south-east coast this elevation has amounted to about 200 yards, and the marks which denote the ancient line of coast, and which have been seen and measured in many points, are so nearly horizontal that the deviation from horizontality cannot be appreciated, a circumstance which renders it impossible to account for the change by assuming a number of small local or independent disturbances. This main question has, indeed, been fairly set at rest by M. Keilhau's important investigations, but it still remains to carry

* A list of the heights of all the principal localities in Norway has been published by Prof. Keilhau in the second part of his work, entitled "*Gæa Norvegica*," a work of great detail, and one of which it is intended to give some account in a future number of the Journal. (Prof. Keilhau's book may be obtained in London from Messrs. Williams and Norgate, Henrietta Street, Covent-Garden.)

out his plan of observation round the great bays of Norway and the adjacent islands, and, following the curves which mark former levels, to measure their height above the sea at points sufficiently near each other to make sure of the elevation having taken place at every point between them. This is an enormous undertaking when we consider the vast extent of the coast line of Norway, but it may be broken up into a number of parts, any one of which may be undertaken by an ordinary traveller, and I may add that the results obtained offer conclusions of sufficient interest to induce the traveller so to occupy himself.

With the view of assisting in this work, I have taken advantage of my stay of a year in the province of Finmark (the most northerly part of Norway), making myself familiar with the class of facts alluded to, the importance of which was suggested by M. Elie de Beaumont, and endeavouring by a system of measurements to complete the lines of ancient sea-coast from the furthest extremity of the Bay of Alten to the little village of Hammerfest, a distance of about fifty miles.

When I have given to the reader the actual result of my observations, I may be allowed, perhaps, to point out some analogous facts observed in other parts of Arctic Norway and in the southern districts of the same country, besides others in Sweden, at Spitzbergen, and even in the north of Scotland, since this statement will not be without value as illustrating and rendering more valuable the result of my own labours.

The Bay or Gulf of Alten (*Alten-fjord*) is one of the most remarkable in Finland. Its direction is N.N.W. and S.S.E., and a double range of islands intervenes between it and the ocean. Sounds, or narrow and deep channels separate these islands from each other, and from the main land, and these, as well as the fjords or firths might almost be considered as true lakes, were they not affected by the tides and marine currents of the Atlantic.

The shores of the sounds are with one exception escarped and high, and the valleys are short and narrow, and rapidly shelving, so that for the most part a considerable alteration in the height of the water makes but little difference in the form of the coast line, and this circumstance is extremely favourable for the determination of the lines of ancient level, since these are little removed from the present shore; and coasting along the shore with a boat I stopped wherever I could find indications of an ancient beach, and in a few minutes, by means of the barometer, obtained materials for determining the height.*

§ 1. *On the two principal Lines of ancient Level.*

There are two very distinct lines of ancient coast, which correspond, without doubt, to two distinct periods of elevation in

* The heights thus taken are all published in the original memoir. They are measured from the mean level of the sea, the mean being taken according to a method described at the close of the memoir. — Ed.

this district. Besides these, there are, perhaps, others that are intermediate, but if so, being less clearly indicated, the consideration of them may be postponed at present. The two principal lines are traceable on the coast parallel to one another, and in spite of frequent interruptions they re-appear sufficiently often, and at intervals near enough to render their former continuity perfectly clear. They may be denominated respectively the upper and the lower line.

The valley of the Alten-elv is situated at the southern extremity of the fjord, and near the village of Elvebakken. At the point where the little river Alten empties itself, there is a remarkable bed of alluvium, brought down no doubt by the stream, and from the Kongshavnsfjeld as far as this village, there occurs, 68 metres above the actual sea-level, a singular horizontal terrace terminating towards the sea by a rapid slope, and forming, parallel to the coast, a considerable curve, about a mile and a half in length. The eastern extremity of this platform juts out towards the north-east, in a sharp spur, the base of which is being gradually worn away by the waters of the river, so that the little hill formed by the spur is daily diminishing on this side. It is easy to see that this spur is composed of sand, but the side not exposed to the action of the sea is covered with such vegetation as is found in the neighbourhood. Advancing to the north-eastern extremity of the terrace the observer is able to perceive similar heaps on the other side of the stream, formerly no doubt connected with these just described, and offering proof of the whole having been once continuous, the level of the river being then the same as that of the terrace. The terrace is traceable from point to point on the left bank, always on the same level; but in consequence of the inclination of the bed of the stream, its surface is gradually at less and less distance; and at a village five or six leagues in the interior the line is only about 28 metres above the general level of the district.

Proceeding from this spot doubtful indications of similar phenomena were observed on the denuded flanks of an escarped promontory in the neighbourhood, and thence to Skodevara, after passing which latter mountain we reach a valley, entirely occupied by a thick mass of detritus, the upper surface of which forms a beautiful terrace, where the continuance of the external ridge of the platform is hardly interrupted, and its horizontality is a striking feature.

Still further on, at the bottom of the Alten-fjord, we find another bay and a third terrace at the embouchure of a small stream (Kaafjord-elv), the right bank of which is steeply scarped, and the left almost entirely occupied by recent alluvial deposits. The whole surface of the terrace is clothed with vegetation, and there is a gentle, but perceptible, slope observable from the line at which it meets the mountain side, as far as the cliff which overlooks the mouth of the stream.

The line of junction of this terrace with the mountain may also

be traced towards the S.E., preserving its horizontality, and becoming a *line of erosion*, the rocks being worn and removed from their original position by the action of the water. A second terrace, not less horizontal, may also be noticed on the right bank of the river, much narrower, but corresponding in its height above the sea with the one just described, and like it terminating in a line of erosion. The two were, no doubt, formerly united, and have been divided by the little stream above alluded to, and, indeed, at the actual mouth of this river there is a delta, reminding one of the ancient delta formerly deposited on the upper level of the terrace, when the waters of the fjord reached to that level.

The mean height obtained by barometrical measurement of this terrace is 68·4 French metres*, and the mean of the observations of this and two other terraces alluded to give 67·4^m, as the difference between the actual level of the sea, and the line anciently reached by the sea along the whole of the southern side of the Alten-fjord.

Other indications, however, of the same kind seem to give evidence of the existence of a period during which the land was stationary at an intermediate elevation. These indications consist of a terrace more or less accurately parallel to the one already described, and presenting an appearance analogous to that of the parallel roads of Lochaber, described by Macculloch, Darwin, and other English geologists.

In the case before us this narrow shelf or road, not unlike a towing path along the banks of a canal, forms a sort of ledge comparatively horizontal, and about ten yards wide, very manifestly interrupting the general slope, which has an inclination of 30° or 40°. In other places, where the ledge is not so manifest, there is still a marked alteration in the amount of slope at a certain point of the descent. This line is traced from point to point, and the mean of several observations gives 27·7^m, as its height above the sea-level.

From the embouchure of the Kaafjord-elv as far as Cape Oskarnæs, neither this nor the higher line of ancient sea-level were observed, but the condition of the coast is unfavourable, owing to the extensive mining operations carried on in the neighbourhood. Cape Oskarnæs itself is a hill entirely composed of transported matter, of which the summit, whose height is about 40 metres, does not reach the higher of the ancient lines of sea-level. It has been deposited under water, and M. Keilhau considers that it may possibly have been a portion of an ancient moraine, but such view is improbable. The hill which forms the headland is separated from the main land by a low isthmus, permitting us to trace, completely round its conical summit, the indications of a bank, which is here the representation of our lower line of level, and the singular appearance of which has been alluded to by Sir W. Hooker in the narrative of his voyage to this country.

* Nearly 200 feet. The most important of these measurements and the general results will be found reduced to English feet in p. 541. — Ed.

The same line appears again at Cape Krognæs, where there is also a little terrace shut in between two piles of rock, which reminds one, by its situation, of the banks of gravel formed in narrow seas. This terrace is entirely made up of sand and sedimentary débris, and its length is about 50 metres. To the west of the Cape the same terrace reappears still more distinctly, but proceeding onwards in the same direction (towards the west) it is found coasting a part of Meelvig, where it may be observed on the steep face of the mountain as a line of erosion, only indicated by the difference of the angle of the slope above and below it. The mean height of the line here is 24·5^m.

This line has not been traced with certainty in the little creek of Talvig*, but an alluvial terrace, almost accurately horizontal, exists at an elevation of 56·5^m above the waters of the fjord.

The two altitudes just recorded of these lines of terrace at Krognæs and Talvig are, it will be seen, sensibly different from those obtained in the southern part of the Alten-fjord, and the differences are too considerable to be referred to errors of observation. Ought we to suppose that they mark distinct periods of elevation, or is it not possible that the same line of ancient level is now seen at different elevations, varying according to the distance from the coast? This latter supposition is rendered almost a certainty by other observations we shall have to record.

The western part of the Alten-fjord offers no certain trace of the phenomena at present under consideration; but in the narrow bay of Komag-fjord the scene changes, and our two lines of ancient level reappear together, and are continued in the Leered-fjord to the steep face of the rock called Quænklubb. The mean of four observations of height gives 49·6^m as the height of the upper line, and two sets of observations of the lower line give respectively 20·5^m and 18·5^m. There can be no doubt that the upper line is identical with that of the terraces of Sandfald and Quænvig, since no higher line can be traced even on the Quænklubb, a rock very favourably situated for preserving the indications of the former presence of water.

With regard to the lower line, the two measurements are preserved, because they show more clearly the probability of a gradual diminution in the amount of elevation of the ancient level suggested by other observations.

The upper line re-appearing on the western side of the Komag-fjord presents itself there in a manner not easily recognised, and requiring, it would seem, favourable circumstances of time and weather to make out distinctly. Seen at a distance it appears as a perfectly horizontal line, traceable on the flanks of the mountain for a distance of nearly four miles; but it is from the opposite bank of the fjord, and in the afternoon, that it is best seen; since on

* *Talvig, Meelvig* — the bays of the pine and of corn. It is interesting to remark that the pine at the present day is not seen beyond Storvig, and the last barley appears at Elvebakken; but this is only additional proof that the temperature has diminished in these regions even within the historic period.

the spot itself it is difficult to tell where to place the barometer, unless some tree, rock, or tuft of grass has been observed and noted from a distance.

In the Leeredfjord the line is marked at the northern extremity of a little bay by a very distinct horizontal platform, and beyond, on the rocky crags of Quænklubb, as a line of erosion presenting an admirable example of the ancient line of contact of land and water. The two stages of elevation are neatly defined at the lower part of the conical mass of this mountain, appearing as two dark stripes parallel to the shore, and even the inhabitants perceive that the bands are evidences of the former existence of the sea at these elevations. The erosive force of the water has been very energetic at this place, the worn rocks and deep caverns which are seen on the spot leaving much room for doubt as to the exact point at which the barometer should be suspended if we have not beforehand taken care to note it.

The second line is distinctly traceable parallel to the present coast all round the Komagfjord, and the inhabitants of the shore avail themselves of it in fencing their meadows, the fringe of land between it and the sea being green and more fertile than the land beyond, owing, no doubt, to its more gentle slope, and a more recent existence in the condition of the sea bottom.

In the island of Seiland, north of Alten fjord, these lines of ancient level do not seem to be traceable on the northern side of Vargsund; but they appear on the western side of the island. From Komagnæs they may be observed on the opposite shore of the island of Qualøe, and in this island they are also found in Ryp fjord, and again at the Langstrandnæs in the Bay of Hammerfest, and on the border of the lake near the town, and lastly, on the little steep islet of Højøe, which, notwithstanding its small extent, attains a height of from 150 to 200 metres.

The mean of observations made at the two spots, viz. the western shore of Seiland, and the island of Qualøe, give the altitudes 42·65^m and 28·6^m respectively for the higher, and 16·6^m and 4·1^m for the lower level. They are important as showing the gradual diminution of the elevation in this direction.

Following these lines in the island of Qualøe towards Hammerfest, we find the upper one traceable first as a small horizontal platform, and then as a line of erosion, but at last is only indicated by worn rocks which require to be carefully examined to avoid the chance of error. Around the little lake of Hammerfest, the elevation of which above the sea level is only 5·46^m, it appears as an almost horizontal bank, and at one point presents itself as a terrace probably composed of transported matter. The lower line is also traceable with tolerable distinctness.

In order now to bring together into one group the phenomena recorded, let us connect our hypsometrical observations with reference to the following points:—1. The southern part of the Alten fjord. 2. Krognæs and Talvig. 3. Komag fjord. 4. Leeren fjord as far as Quænklubb. 5. The western part of the

island of Seiland. 6. The environs of Hammerfest. We have then the following series * : —

	m.	m.	m.	m.	m.	m.
Elevation of upper line	67·4	56·5	51·8	49·6	42·65	28·6
Lower line = amount of second elevation -	27·7	24·5	20·5	18·3	16·6	14·1
Amt. of 1st elevation -	39·7	32	31·3	31·3	26·05	14·5

The two first series leave no doubt as to the perfect continuity of the lines and the gradual diminution in the amount of elevation. The third series, derived from the others, gives the amount of the first great change of level, and the position of the coast line when the second or lower line was at the actual level of the sea. The first disturbance is thus seen to have been somewhat more considerable than the second, and to have extended with less uniformity along the line of the coast. A considerable difference, indeed, exists between the two last numbers of this derived series, and renders it desirable that we should have further observations with regard to the coast between Rastabynæs and Ryp fjord, and to this subject we shall have occasion to recur. With regard to the absolute amount of each of these changes of level, the outlines which we have here given will require to be modified if we have to intercalate other lines between the two which alone have been hitherto considered.

§ 2. *On other Lines of ancient Level.*

There appear, from various observations along this line of coast, to be two other lines doubtfully traceable besides the two principal ones above described. One of these is intermediate between the two more distinctly marked, and the other is below the lower one. The evidence is not, however, very satisfactory with regard to either of them ; although the former, which we may call the intermediate line, is sufficiently probable to be admitted provisionally.

The first set of observations which the existence of such a line suggested, consists of a dark-coloured band seen on the south-east of Kongshavensfjeld from Bosekop, and having a height of 39·3^m ; of a line of erosion between Storvignæs and Krognæs 38·5^m high ; and a doubtful line near Talvig of 43·1^m, giving a mean of 40·5^m. Near Hammerfest a mean of two or three observations gives 21^m for this same line ; and, according to M. Siljeström, there is an intermediate terrace opposite the town of Tromsøe at a height of 45·5^m.

The intercalation of this intermediate line considerably alters

* The following table gives these measurements in English feet : —

	ft.	ft.	ft.	ft.	ft.	ft.
Upper line	- 221·4	186	169·6	162·3	139·3	92·3
Lower line	- 91·3	80·5	67·3	60	54	46
Amt. of 1st elevation	130·1	105·5	102·3	102·3	85·3	46·3

the relative amount of the earlier and later elevations along the coast, reducing the first or most ancient to 7·6^m, making the second or intermediate movement of 6·9^m, and leaving the third or most recent 14·1^m, and therefore considerably greater than the other two.

§ 3. *Observations and Hypotheses concerning the Formation of these Lines of ancient Level.*

Although the tendency of the waves to wear away the cliffs against which they beat, and form a beach made up of these materials, is a fact sufficiently well known, perhaps it has hardly been considered with reference to its geological bearing, and in relation to the ancient lines of level in certain districts. It is also by no means easy to make out very satisfactorily the causes which have determined the formation of those lines at one place rather than another.

Mr. Darwin, indeed, in his memoir on the parallel roads of Lochaber*, has assigned the following causes as sufficient to account for these differences; namely, the greater or less degree of steepness of the slope; the nature of the rock; the local circumstances favourable to the production of vegetation on the bank, preserving it after the retreat of the waters; and the configuration of the neighbouring coast.

First of all let us distinguish between the terraces formed by lines of erosion and of projection; the first of which offer no serious difficulties, since the terrace is manifestly a local phenomenon exhibited at the mouth of a river or stream of running water, and one which ought to be present at the extremity of each valley so provided. In most of the valleys in the district now under discussion this terrace has been observed, and in the others there is no positive proof of its absence; and indeed it may occasionally have been removed by the very circumstances connected with the elevation.

The exposure of a coast line to a beating surf tends more or less to the formation of a line of erosion; while, on the other hand, direct exposure to the more violent effect of the waves during tempests gives no such well-defined line: and it is doubtful whether we could trace them where the exposure is greatest, namely, on the northern side of the outermost border of islands which fringe the coast of Finmark.

The effect in these northern latitudes of the incessant dash of short broken waves, not rolling in from a wide expanse of ocean, seems to me however to correspond exactly with that presented by the ancient lines of level; in fact, we may observe in more than one spot on the coast analogous lines now in the progress of formation. Such, for example, appear at the promontory of Rastabynæs, where the sea has eaten out for itself a bank strictly resembling that which exists at an elevation of 16 metres above its level,

* Phil. Trans. 1839. p. 60.

where, indeed, the escarpment is singularly characteristic, and identical with that now presented by the rocks below, while the interval between this line and the actual sea level is covered with large pebbles.

Similar appearances may also be noted in the Komagfjord and in the Rypfjord, where the indentation produced in the coast by the sea is very distinct, and the appearance of a projecting bank is manifest to the eye; and a marked tendency to the formation of new banks of this kind may be observed in those spots where the sea still washes at the foot of terraces formed at an earlier period. This latter phenomenon is clearly seen at Sandfald and Hammerfest, and at the mouth of the little stream which empties itself at the bottom of Rypfjord. A like coincidence between the appearance of new and ancient lines of this kind has been observed by Mr. Keilhau in the province of Drontheim*, and it thus appears that we must look chiefly on the flanks of the terraces for those marks, by which to determine the existence of elevations posterior to the first.

The other causes referred to by Mr. Darwin must not be forgotten. The conservative influence of vegetation on banks thus formed must certainly be taken into account in explaining the perfect condition of the slope of the great terrace of Sandfald, between the Kongshavensfjeld and Elvebakken, and the steepness of the slope, although a secondary consideration, certainly ought to exclude from this category the cases in which this inclination is very inconsiderable and does not amount to more than 8° or 10°.

A far more influential cause than the latter is the nature of the rock itself, its tendency to decomposition, and the manner in which its beds or laminae are presented to the erosive action of the waves. It must, indeed, be clear that the position in which stratified rocks are placed with respect to the waves will have great influence on the effect produced, and that a rock little affected by atmospheric exposure, but readily worn away by the action of the waves, will long retain the marks of erosion, while if the conditions are different the result will be greatly different.

The mountains of Alten-fjord and of all this part of the coast belong to the group of metamorphic rocks, but the nature of the rock differs widely, since calcareous beds are found at Storvignæs and at Talvig, between Korsnæs and Skillifjord; amphibolic rocks on the island of Seiland and near Hammerfest; while diallage, quartzose sandstones, and argillaceous schists are not rare. I have not myself been able to judge of the relative influence of these rocks on the different phenomena of the neighbourhood.

The last cause noticed by Mr. Darwin is the situation of the line relatively to the surrounding coast lines; and that geologist has concluded, from the examination of these lines at Lochaber, that an inland situation is favourable to the formation of the banks. According to this view, we ought rather to find indications of them

* *Nyt Magazin for Naturvidenskaberne*, vol. xi. p. 54.

at the bottom of the fjords than along their shores or at the headlands by which they are terminated seawards.

On the other hand, according to Sir T. D. Lauder*, the promontories are the places where we should chiefly look for them. An inspection of the map prepared by the commission† appears not to accord with the remarks of Mr. Darwin; but I must observe, that I have not myself visited the greater number of the larger fjords and sounds along the coast, and have not penetrated to the bottom of several others, the investigation of which is necessary to carry on these lines of level and fill up the gap which separates the Komag-fjord from Kongshavnsfjeld. However this may eventually prove, there can be no doubt, *à priori*, of the efficacy of the cause in question considered generally. Amongst the currents, those parallel to the direction of the coast penetrate less into the fjords than the sounds; but all of them may occasion here and there submarine deposits, which, reaching the shore, may there determine the formation of a bank, which otherwise would have no existence.

The prevailing winds, which are here most terrible when proceeding from the north-east, take a certain definite course, and drive the sea along in well-marked directions, and from these and other causes there seems to me no need to have recourse, with M. Keilhau, to great drifts of ice in order to account for these lines of erosion: and indeed the debacle of ice along these coasts is comparatively unimportant, the fragments being almost lost before reaching the Vargsund, so that we must presume very different atmospheric conditions to have obtained in order that this cause could be very energetic.

The remains of marine animals, the erratic blocks, and the rocks polished and marked with parallel striæ form three groups of geological facts, having reference to the phenomena we are now considering; they have been observed by M. Keilhau to recur along the whole extent of the Norwegian coast, even into Finmark; the marine remains appearing among deposits, the formation of which is intimately connected with that of the terraces and other marks of the former presence of water. In Finmark however, the localities in the interior whence marine shells are obtained are hitherto few in number, and indeed it is only at Talvig that I have obtained proof of the existence of fossils above the level of the sea; but this is partly accounted for when we consider how few are the excavations in a country but thinly peopled, and where the houses are merely wooden edifices placed upon the surface. At Talvig however, by digging about half a metre below the surface in a sheltered part of the bay, we laid open a clayey bank containing *Mya truncata* and *Tellina Baltica*, some of the specimens being remarkably fresh and even showing vestiges of the epidermis. This bed was 7 metres above the sea

* Ed. Phil. Tr. 1839. p. 10.

† This map the translator has not been able to avail himself of.

level, and appeared identical with one described by M. Keilhau as common on the coast. A little before my visit to Talvig, a bluish clay had been dug out in making a small harbour or basin for boats, and in this was contained fragments of dead shells just like those obtained from a bed a little above, but yet more perfect, and even showing the dried fragments of the animal, so that we had here a bed in actual course of formation to compare with one at a higher level.

I have likewise received other shells (*Patella* and *Venus*) collected near Storvig, at the western extremity of the island of Söroö, in a sandy deposit a few metres above the level of the sea. The elevation in this case is said to be about 30 metres. It may be worth noticing that the absence of organic remains in the sedimentary terraces of Sandfald, &c. is no proof that the sea did not formerly reach those higher levels, since the very current of fresh water to which the formation of the terrace was owing would drive away the marine animals inhabiting shells.

M. Keilhau has observed, that the subject of erratic blocks is connected with that of the last changes of level of the land; I have noticed that these blocks abound in Finmark, and are there of a very considerable magnitude, one of them for instance a little south of Bosekop, not being less than 3 or 4 metres in height and 8 metres in its other dimensions. I have observed further, that these blocks are chiefly abundant a little below the level of our lower line, and as examples of this we may notice the group situated between Fogedgaard and Bosekop, and the infinite multitude between Hammerfest and the mouth of the little stream proceeding from the neighbouring lake. No doubt these blocks are found at other elevations, but their predominance at this is not less worthy of notice. The ice-bergs which then perhaps visited and were run aground in these fjords and there deposited the fragments of rock concealed in them, will perhaps ultimately be found to explain and account for these phenomena.

Let us consider next the parallel striæ on the rock, a subject of special inquiry, concerning which the first observations seem to have been made by M. de Lasteyrie. The furrows and polishing of the rocks is very evident on the mountains of this district, and the Kongshavnsfjeld and the Skodevara offer admirable instances, while along the coast of the gulf of Bothnia, especially in the Swedish province of Angermanland, the same appearance is frequent so far as regards the polish on the rocks and the parallelism of the channelling, but the direction of the markings is different. The furrows observed in Finmark are however analogous to those of Sweden, and doubtless owing to the same cause. They may be observed at considerable heights, and also near the sea level; and one little island, that of Bratholm, whose highest point is not more than 45 metres, is entirely polished and resembles the hulk of a ship keel uppermost, the seams running along the whole length parallel to one another. Observations with refer-

ence to this subject are left for the special consideration of M. Siljeström.*

In order to arrive at an explanation of these phenomena which shall be at once uniform and precise, the expressions *ancient level of the sea, elevation, elevatory force*, have been introduced in this memoir, but without any idea of prejudging the question, and merely because such language is common among geologists. Although a complete examination of the many different ways of explaining these phenomena does not at all enter into my plan, I shall offer some remarks on the different hypotheses as I briefly enumerate them.

It is clear in the first place that the great difference of level between the extreme points of our line of elevation, renders it quite impossible to explain the existence of these lines by the fracturing of the barrier of some ancient lake; and I cannot but suggest that an accurate geodesic levelling should be applied in the case of the doubtful lines in Scotland, for this would at once determine the possibility of such an explanation being correct.

Some authors have remarked, that a simple alteration in the arrangement of the masses in the interior of the earth, might, by changing the direction of its weight over a greater or less extent of surface, depress or elevate the level of the water, and as a consequence of the displacement of the vertical change even the horizontality of ancient lines of level. Theoretically this may be true, but if we consider the two series of numbers given above†, it will be seen that such an explanation fails entirely, for while one series (that relating to the most recent elevation) may appear to harmonise with the theory, the other exhibits far too rapid a diminution in the passage from the last term but one to the last.

If it be assumed that the terraces and lines of erosion may be due to powerful currents setting in from the valleys in the interior towards the North Sea across the fjords and the sounds, it will be necessary to explain, 1st, the presence of marine organic remains; 2. the reason why the lines of level do not gradually but sensibly rise towards the extremities of the valleys affected by the increase of the slope suddenly bringing the banks of the streams under this local influence; and, 3. whence was derived the enormous rush of water necessary to cover, for a considerable time, not only the valleys and fjords of Finmark, but also, doubtless, the whole of the Norwegian coast.

Polished rocks, as well as erratic blocks like those of Scandinavia, are found also in Switzerland, and it has been supposed, M. Agassiz having formally stated his concurrence with the view, that they had a common origin. According to this view, glaciers on a far grander scale than those which exist at present, once occupied all the valleys, and by their progressive downward movement produced all these appearances. Such an hypothesis may, indeed, account for the erratic blocks and polished and striated rocks of these countries;

* One of M. Bravais' coadjutors in this commission. — ED.

† See *anté*, p. 541.

but it can hardly refer to the terraces and lines of erosion in Norway, which manifestly and necessarily belong to a different order of phenomena.

Lastly, with regard to the hypothesis of elevation itself, I can hardly assert that it fully satisfies all the points of the case. The possibility of explaining in this way the appearances presented on the coast of the Scandinavian peninsula was suggested by Playfair, and even before him, according to M. Keilhau, by the Danish author Jessen. Von Buch, after his return from the North, and without being aware of what Playfair had said, expressed the same opinion, and added, that the nature of the elevatory movement in Norway was different from that on the shores of the Baltic. "Hence it results," he observes, "that the shelly bed of Tromsøe owes its existence to other causes than those which gradually elevated Sweden above the sea level."* M. Keilhau, after having clearly demonstrated this latter fact, showed also that the whole change is the sum of a certain number of successive changes which have alternated with periods of repose, and that Norway has thus been elevated by impulsive upheavals or jerks. He illustrated the length of the intervals by the slow rate of submarine deposits of the same kind now and the thickness of the deposits that have been elevated, stating that there were no grounds for assuming that they were formed under any different conditions; and lastly, he added, "if there is no doubt as to the existence and long duration of periods of repose, there is still a question as to the duration of the elevatory movement. We do not know whether it took place suddenly, like that on the coast of Chili, or whether, like that of the neighbouring shores of Sweden, it was of extreme slowness, although the proximity of the latter district is an argument in favour of the same process being followed. If such is the case, the Norwegian coast is at the present day in an interval of repose, while that of Sweden is undergoing elevation."

§ 4. *Other Lines of Ancient Level in Northern Europe.*

The accounts of travellers in many parts of Northern Europe record phenomena similar to those we have been considering. It may be worth while to allude to some of these.

Five leagues only N.N.E. of Hammerfest, on the island of Rolfsøe, M. Martin has seen a terrace about 6 metres above the sea, covered with rolled flints, and exhibiting three successive steps or stages.

On the island of Maasøe, in 71° N. lat., about 36 marine miles N.E. of Hammerfest, an ancient line of level, 34·8 metres above the sea, was visited and described by Hell; and in Varanger fjord, the most westerly of the Norwegian gulfs, similar terraces have been observed by M. Keilhau, 63 metres above the sea. These two observations probably refer to the continuation of our higher line.

In the Lang fjord, one of the friths of the Bay of Alten, a line

* Von Buch, *Voyage en Scandinavie*, traduction d'Eyriès, vol. i. p. 424.

of erosion has been traced also by M. Keilhau, 16 metres above the sea; and this, which is probably our lower line, recurs at Lögsund, 36 marine miles W. of Talvig, at $70^{\circ} 10' N.$ lat., and again at Tromsøe ($69^{\circ} 40'$): the terraces opposite which town are of the same kind, and have been described by M. Siljeström.

Other lines are cited at Lenvig ($69^{\circ} 20'$) and at Gebostad ($69^{\circ} 15'$), but the appearances of this nature become rarer as we approach Trondiem, reappearing, however, in the northern recesses of the great fjord of Trondiem.

Mr. Laing has described indications of ancient sea-beaches 60 English feet ($18 \cdot 3^m$) above the sea near Fossum, seven English miles in the interior; but the elevation in these latitudes soon becomes of a different character, and marine shells are found at no great distance at a height of 400 or 500 feet. South of Trondiem these lines have been observed at various elevations.

Lastly, the ancient line of level of Nord-östre-fjord, in latitude $60^{\circ} 35'$, appears to be $43 \cdot 3^m$. It is impossible to trace these lines very decidedly at so many distant and detached points; but it would seem probable that the upper line retains an altitude of from 150 to 200 metres along the south and south-eastern coast of Norway.

On the coast of Sweden observations of this kind are still more rare than in Norway; but proofs of the comparatively recent elevation of the land are not wanting. The case at Uddevalla is well known, and the presence of marine shells of recent species in beds above the sea level has been recorded at several points of Western Sweden by M. Hisinger and Mr. Lyell; and the absence of evidence of this kind on the eastern side is probably owing to the lowness of the coast line, the distance inland at which this evidence must be sought, and the easy destruction of the indications that were left. I shall not depart from my plan in giving here two observations made on my return in this district.

Near the mouth of the Pitea, at a little distance to the north of its banks, the high road from Tornea to Stockholm runs along the foot of a terrace, about 15 metres high, like those of Finmark. The bank or terrace on which the road is constructed itself forms the first intermediate descent, and is about 20 metres above the river.

The road from Stockholm to Gottenburg opens into the valley of the Götha, at about 4 leagues from the town, by a secondary valley, tolerably wide, and nearly perpendicular to the river, where the confluence occurs; and on the other bank of the stream a long hill may be observed, flattened at the summit, and parallel to the principal valley, and a line of erosion or projection of the most striking kind marks with a deep recess and for a considerable distance the eastern side of the mountain at an elevation of about 30 metres. The small distance of this spot from Uddevalla and from the Norwegian coast renders it probable that this line is really of marine origin.

But it is well known that these proofs of the changes that have

taken place in recent geological periods, affecting the relative level of land and sea, are not confined to the Scandinavian peninsula, and possibly there are few lines of coast that will not offer them on close investigation. They have been recorded on the shores of Spitzbergen, in the north of Scotland, in several places on the coast of England, and the coasts of France do not seem to form an exception to the general law. But in approaching the temperate zone indications of this change are found to be frequently obliterated by various agricultural and other operations, so that it is hardly possible to compare the phenomena in these districts.

The establishing the possibility of tracing these lines of ancient level for a considerable distance, and the placing beyond a doubt the continuity of the line observable only at detached points; the existence in Finmark of two distinct lines of this kind, and of one less certain; and lastly the proof that the lines are neither strictly parallel to one another or to the present level of the Arctic Sea: — these may be considered the general results of the labour here recorded.

With regard to the numerical data, they are not at present so important as might be wished, owing principally to their isolation and the smallness of their number; but they will increase in importance in proportion as additional exact observations furnish new documents to this pre-historical hydrography. Thanks to the enlightened care of the Norwegian government, even the least accessible districts of that country are becoming more accessible, especially to those sons of the north, so zealous and so learned, to whom we are indebted for the great and rapid advances that have been made during the past century in the natural history of Scandinavia. Under such favourable circumstances, geological science may safely expect some light to be thrown even on these obscure questions.

NOTE. — The author then, in some remarks appended to his memoir, states that he obtained a line of departure or a base line for his measurements, from the observation of the growth of a fucus (*F. vesiculosus*), very abundant on the northern shores, and ranging between high and low water about 0·6^m above the mean height of the water. In this way the observations could be readily made at any time of the tide and with little danger of error.

In order to obtain the ancient mean level, the re-entering angle of a line of erosion, or the highest point of the edge of a terrace, was taken for the place of admeasurement wherever it was practicable; but these points are not absolutely correct, and there is necessarily a source of error, the limit of which is stated from some observations made in the neighbouring seas to amount to 1·5^m; but M. Bravais considers, that by more accurate and extensive observations a mean might be ascertained. The whole of this correction must of course be deducted from the calculated amount of the last elevation.

M. Bravais adds, that if at the time when observations of this kind are being made, the amount of erosion at present and at former times could also be recorded, and the historical data added as to the *minimum* number of years that have elapsed since the latest elevation, we might perhaps obtain the means of determining an inferior limit of the duration of those periods of repose during which the ancient lines of level have been in the course of formation.

D. T. A.

II. *On the Geology of the ALTAI MOUNTAINS.* By M. de TCHIHATCHEFF.

[Communicated at the meeting of the French Geological Society at Chambéry in 1844.* Vide *Bul. de la Soc. Geol. de Fr.* 2^{me} ser. tom. i. p. 674.]

THE district of the Altai mountains, as described by M. Tchihatcheff, is situated in Central Asia, between latitude 49° and $52^{\circ} 30'$ N., and longitude 79° and $86^{\circ} 20'$ east of Paris, and is described as extending for about 500 miles in one direction, by 220 in the other. It abounds in lofty mountain peaks, and is traversed by vast rivers, the length of whose course is only surpassed by that of the Amazons, and the Mississippi in America, the Yang-Tse in Eastern Asia, and the Nile in Africa. Of these rivers the Ob is the principal, and it is fed by a number of very considerable streams, almost all of which exhibit a striking contrast in the relative level of their two banks, the height of the right bank being considerably greater than that of the left.†

The direction of the principal streams which traverse the Altai district exhibits a general agreement with that of the mountain chains, and also with the strike of the different groups of strata. Combining the observations that have been made with regard to these points, the whole tract may be subdivided into two districts, the western and the eastern, the former extending between the river Ob and the northern zone of the river of Katoune, in which the prevailing direction of the mountain chains is N. W. and S. E., and the latter including the central and southern district of the river of Katoune, and extending to the borders of the Sayanes, the direction of the mountain chains in it gradually altering from that in the former district, and terminating by running from N. E. to S. W. It is interesting to find that this change in the direction of the mountain chains is accompanied by marks of disturbance in the folds and contortions of rocks, and by the appearance of curved and broken lines of high ground, which are very strikingly shown, and are, indeed, evident by a mere glance at the map of the district. In the steppe of Tchouya this arrangement of a series of heights in the form of a natural amphitheatre takes place in rocks composed of clay slate, and all the masses, shaped into the form of gigantic craters, or of lofty crests, folded as it were back upon one another, and strikingly resembling the configuration of igneous

* The observations of M. Tchihatcheff, the results of which were communicated in this notice to the French Geol. Soc., were also offered to the Academy of Sciences, and a report on the subject by Messrs. Brongniart, Dufresnoy, and Elie de Beaumont appears in the "*Comptes Rendus*" of the 12th of May (vol. xx. p. 1389.). We learn, also, from a late number of the *Bulletins de la Soc. Geol. de France*, that M. Tchihatcheff has now published his great work, of which the outlines are here given. — ED.

† This is the case too with the rivers in Northern Siberia, and also with the Volga and others of European Russia. See "*Russia and the Ural Mountains*," by Mr. Murchison, M. de Verneuil, and Count Keyserling, vol. i. p. 650. — ED.

rocks, are also in fact enormous sedimentary deposits more or less metamorphosed. It appears to be the case that one of the prevailing features in the general contour of the Altai consists not only in a terrace-like arrangement of the great masses which compose it, but also in a certain rounded or swelling outline of these terraces, suggesting the agency of plutonic forces beneath the surface, sufficient to produce these undulations of the sedimentary crust and the frequent metamorphism, but often without leaving any marks of violent disturbance or disruption, and without the presence of igneous rocks at the surface to account for the alterations that have taken place.

The more ancient rocks of the Altai present, in some places, the apparent anomaly of perfectly horizontal stratification, immediately adjacent to indications of disturbance more or less violent, and one result of this, especially in the eastern part of the district, is recognised in the absence of bold and picturesque outlines, and the prevalence of those smooth rounded contours and straight lines which fatigue the eye of the traveller, and which may be compared with the appearance of the well-known Sierra Nevada of Spain, probably produced by the same geological structure, and exhibiting the same character along a line upwards of 120 miles in length, presenting a strikingly dreary and monotonous appearance. The districts of this kind in the Altai consist, as in Spain, of a long ridge with a flattened summit composed of horizontal beds not accompanied by any rocks of decidedly plutonic origin, but composed of mica schist and clay slate passing into chloritic schist, all probably of the older palæozoic period.

The structure of the Altai district, as indicated by the direction of the mountain chains, is fully confirmed by geological investigations concerning the strike of the different beds; those in the western district running N. W. by S. E., and those in the east at right angles to this direction. Where these two lines of elevation cross one another we may remark on the one side that kind of interlacing and entanglement by which the system of the Saïansk is almost everywhere confounded with that of the Altai, properly so called, and on the other side the considerably greater altitude of the mountains of the eastern compared with those of the western district. The highest point of the Altai range is precisely in the intersection of these two axes of elevation, and the lake of Teletzk in the immediate vicinity of the intersection is also due in all probability to the same geological causation. The eastern Altai is, however, remarkable for the number of lakes of great depth which abound in it, while, with the exception of the celebrated Lake of Kolyvan, the western district contains few worthy of note until we reach in its western extremity those singular salt lakes which belong to a different group of geological phenomena. The date of the elevation of the western Altai seems, from some appearances, to have been contemporaneous with that of the Ural.*

* With reference to this subject the author in the *résumé* quoted, offers some

The plutonic rocks of the district under discussion consist of granite, syenite, quarziferous porphyries, eurites and melaphyres, the mutual relations of which, though often difficult to make out, seem to lead to important conclusions with reference to the sedimentary deposits, almost all of them in fact being more modern than these latter, and proving, by their relations with the metamorphic rocks, that none of the igneous rocks of the Altai are in the strict sense of the word "primary," or in other words, portions of the original solidified crust of the globe.

Rocks of mechanical origin occupy the greater part of the Altai district, and with the exception of some diluvial deposits, they all appear to belong to the older or palæozoic series. I have been able to determine positively the following groups, viz.:—*a.* Devonian formations; *β.* carboniferous limestone; and *γ.* uppermost beds of the coal measures or possibly of the Permian series.

a. Devonian Rocks. Rocks of this period (so far as my investigations, limited certainly to a small part of the whole area occupied by them, enabled me to judge) are distributed in three regions separated from one another by other ancient but non-fossiliferous strata, or more frequently by granitic rocks and diorite. These three regions I have designated the basin of Zinieff, that of Tomsk, and that of the river Yenesei, extending between the mouth of the Ambakaya and the town of Krasnoyarsk. From the two first of these I obtained fossils, of which the following is a list, viz.:—

Calymene macrophthalma	Cyathophyllum turbinatum Goldf.
Terebratula prisca var. explanata	C. hexagonum
T. resembling T. ventilabrum	C. helianthoides?
Spirifer speciosus	C. quadrigeminum?
S. alatus	Petraia celtica Londs.
S. resembling S. Verneuli	Calamopora fibrosa Goldf.
Leptæna, resembling L. lata	C. spongites
Orthis crenistria	C. polymorpha
Producta subaculeata	C. infundibuliformis
Stromatopora concentrica	Retepora retiformis.

together with numerous fragments of Orthoceratites and stems of encrinites.

β. Carboniferous Limestone. The carboniferous like the Devonian rocks are grouped in three detached basins, from each of which I have obtained fossils more or less characteristic. The fossils obtained from these basins are the following:—

Orthis arachnoidea	Producta punctata
Spirifer mosquensis	P. resembling punctata
S. trigonalis	Retepora membranacea Phil.
S. Bronnianus	R. retiformis
Producta antiquata	Eschara scalpellum Londs.

conjectures founded on the parallelism, or supposed parallelism, of the Altai, with other known mountain chains. From an answer to an observation made by M. de Verneuil, in the course of the subsequent discussion (also recorded in the "Bulletin") it appears that these conjectures are hardly sufficiently grounded to satisfy even the author himself. — Ed.

γ. Deposits, which may be considered as intimately related with those of the carboniferous series and forming the uppermost portion of them, perhaps, indeed, belonging to the group now described as *Permian*, occupy an extensive basin, which I have designated "the basin of Kouznetzsk," from the city of that name situated near the middle of the district. In this wide extent two localities are especially remarkable by their palæontological characters, namely, the village of Afonina and the banks of the river Inia, and both are especially rich in the trunks of fossil trees, which have been the subjects of investigation by M. Gœppert. The following is a list of the different species of vegetable markings and trees found in these deposits : —

<i>Anarthrocanna deliquescens</i> Gœp.	<i>Næggerathia æqualis</i> Gœp.
<i>Neuropteris adnata</i> Id.	<i>N. distans</i>
<i>Sphenopteris imbricata</i> Id.	<i>Araucarites Tchibatcheffianus</i> Gœp.
<i>S. anthriscifolia</i> Id.	

The probable absence in the Altai district of any deposits more recent than those of the palæozoic period corresponds in a remarkable manner with the similar absence of trachytes, properly so called, of basalt, obsidian, lavas, and generally of all rocks characterising periods comparatively modern. This circumstance not only constitutes one of the most striking distinctive characters between the Altai district and America, Hungary, Turkey in Europe, the Phlegræan fields, the Island of Java, &c., all of which exhibit trachytic rocks and lavas, but it also distinguishes western from eastern Siberia. In fact the great extent of country eastwards from the Yenesei exhibits basaltic rocks, phonolites, trachytes, species of obsidian, perlites and lava currents (as at Kamtchatka), associated with secondary deposits not occurring in the Altai. The peninsula of Kamtchatka also, which, of all these vast regions, is the one best characterised by modern phenomena of eruption, contains the most recent sedimentary rocks hitherto discovered in Siberia; since, according to M. Ermann, cretaceous rocks fringe a considerable part of its western shore, and are flanked by a broad band of tertiary deposits. It is, therefore, probable that a part of Eastern Siberia, especially the tract watered by the river Lena, between Yakoutsck and the mouth of the river, including several islands in the Arctic Ocean situated near the mouth, have been elevated more recently than that part of Siberia stretching westwards to the Saïansk mountains. Perhaps hereafter, when our knowledge of Central Asia is less vague, this line may be extended to include the great chain of Thian-Chan, if indeed the cautious policy of China should allow us to examine more closely the volcanic cones and craters, whether recent or still in action, in the western governments of that vast empire.

If, however, in respect of geological age, the greater part of the Altai finds its representatives in the older formations of Asia, Africa, and America, this district is not less strikingly distin-

guished from those countries by some palæontological peculiarities. It is true that the very superficial knowledge that we possess of the fossil flora and fauna of the Altai will not enable us at present to establish a comparison between these few fragments and the great series of fossils found in Europe, but even the little at present known appears to justify the following remarks, although they may hereafter, when we know more of the subject, require some modification.

The genera *Nautilus*, *Goniatites*, and *Posidonia*, so characteristic of the carboniferous limestones of England and the Rhenish provinces, appear to be entirely absent in the analogous deposits of the Altai, and in the same way *Strigocephalus* and *Murchisonia* which abound in the Devonian rocks of the Rhenish provinces, and in Devonshire, have not here left any traces of their existence.

The class of fishes also is absent, or at least is by no means so characteristic as in other Devonian districts.

Now it would seem that with regard to the rarity of *Cephalopoda*, the old rocks of the Altai offer analogies rather with America than with Europe, since, according to the Count d'Archiac and M. de Verneuil *, these fossils were much less abundant in the ancient American than in the European seas. The Altai however is far behind even the former in this respect, for there have only been found at present, so far as I am aware, *Goniatites Henslowii*, *G. Listeri*, *G. carbonarius* and *G. sphaericus*, fossils extending over an immense area, some of them occurring in various parts of Europe and in the United States, and even in India, according to M. Von Buch, who has found *G. Listeri* on the banks of the Ganges. The genus *Orthoceratites* is also rare in the Altai, compared not only with its abundance in the ancient formations of Europe, but even in America, where the fewness of the species appears to be made up by a greater variety of generic forms.

It would seem to result from the preceding observations that, at the period of the deposit of the palæozoic rocks of the Altai, the sea presented a well-marked difference in the nature of the pelagic fauna, distinguishing it in this respect from all the contemporaneous seas. This difference has stamped the fauna with a peculiar character, which at the present day is to be observed in northern seas, as compared with those of the temperate and tropic zones, namely, 1. poverty in the number of orders, genera, and species; 2. great relative abundance of individuals; and 3. certain restrictions in the development of individual forms, compared with their congeners of warmer countries.

These three peculiarities seem in fact combined in the Altai fossils, for they are not only remarkable for the fewness of the genera and species, but also by a certain reduction in external dimensions, so that enormous masses of rock appear to be made up of a vast multitude of small fossils, the larger analogous forms of the Cephalopodous and Brachiopodous families failing entirely, and

* Geol. Tr. 2d ser. vol. vi. p. 329.

being only replaced by these minute representatives. The only apparent exceptions to this general condition are seen in the animals of lowest organisation, such as the species of *Calamopora* and *Cyathophyllum*.

The examination of the fossil flora of the Altai (although at present confined to the specimens brought by myself from the carboniferous rocks) appears to conduct us to results of the same kind as those arrived at by the investigation of its fossil fauna. Among the numerous trunks of fossil trees and vegetable impressions collected from the extensive carboniferous basin of Kouznetzk, we may trace a poverty of generic and specific types, compared with the fossil flora of contemporaneous formations in Europe and America, although the specimens examined almost all belong to new species. Those that have been described again are mostly referred to *Coniferæ*, in so far therefore exhibiting a tendency to approximate to the condition of existing creation, and indicating a less tropical flora than that of other countries during the same epoch. Whilst indeed the carboniferous rocks of Europe and America contain a multitude of the remains of plants, such as *Lepidodendron*, *Sigillaria*, &c., whose nearest analogues are to be sought at the equator, the same rocks in the Altai are more especially characterised by species which, like *Araucarites*, present the greatest analogy, if not a perfect identity with plants which still form immense forests beyond the tropics, the *Araucaria* not only abounding in New Holland, but attaining in Norfolk Island gigantic dimensions, not inferior to those of the largest specimens found in a fossil state.

The Altai district therefore, whether considered with reference to the direction of its mountain chains and other physical features, or with regard to its fossils, appears to have little relation with the geological formations of Europe and America. Differing, also, not less from the mountain district of European Russia, the vast expanse of Western Siberia is as it were isolated, and claims in its geological description a separate consideration, destined perhaps some day to be connected with investigations concerning the geological constitution of northern and central Asia.

D. T. A.

IV. NOTICES OF NEW BOOKS.

- I. GEOLOGICAL OBSERVATIONS *on the Volcanic Islands visited during the voyage of H. M. S. BEAGLE, together with some brief notices on the geology of AUSTRALIA and the CAPE OF GOOD HOPE; being the second part of the Geology of the Voyage of the Beagle, under the command of Capt. Fitzroy, R. N., during the years 1832 to 1836.* By CHARLES DARWIN, M. A., F.R.S., V.P.G.S., Naturalist to the Expedition. London, pp. 176. with a map of the Island of Ascension.

ALMOST the whole of this Second Volume of Mr. Darwin's narrative is occupied by descriptions of volcanic rocks of various geological ages met with in the island of St. Iago (one of the Cape de Verdes), in Ascension Island, in St. Helena, and in some of the islands in the Galapagos Archipelago. Besides these descriptions, however, the work contains notices of rocks occurring in a few other islands, and some general considerations on trachyte and basalt, and on the distribution of volcanic islands, in addition to notices on Australia and the Cape of Good Hope, alluded to in the title.

As Mr. Darwin's observations chiefly relate to matters of fact, and are by no means diffusely expressed, it would not be possible in a short notice even to touch upon all the matters discussed and described in this work. It will be more to the purpose to consider the general views of the author with respect to volcanic products and to communicate his views concerning the cause of the upheaval of volcanic craters and islands, and the distribution of these islands on the earth.

Mr. Darwin observed with regard to the islands of St. Helena, St. Iago, and Mauritius that all three are bounded (at least in the parts he examined) by a ring of basaltic mountains, now much broken, but evidently once continuous (p. 93). The average inclination of these mountains is, however, greater than that which could have been acquired by lava flowing down a sloping surface, and all three islands have been raised in mass. The following ingenious conjecture is offered to explain these circumstances:—"That during the slow elevation of a volcanic district or island in the centre of which one or more orifices continue open, and thus relieve the subterranean forces, the borders are elevated more than the central area, and that the portions thus upraised do not slope gently into the central less elevated area, but are separated from it by curved

faults. By this hypothesis, the elevation of the districts in mass and the flowing of deluges of lava from the central platforms are likewise connected together, and the marginal basaltic mountains of the three islands alluded to might thus still be considered as forming 'craters of elevation,' the kind of elevation implied having been slow, and the central hollow or platform having been formed, not by the arching of the surface, but simply by that part having been upraised to a less height." (p. 96.)

The formation and position of crystals, whether of albite or other volcanic minerals, in basalt, is a subject of considerable interest, and is connected with that of the order of eruption when trachyte and basalt are both present. Observations on this subject, and relating to the spontaneous separation of certain minerals and the formation of dykes in partially cooled rocks, are of the greatest interest to the geologist, since almost every region in which igneous rocks are extensively distributed abounds also in trap dykes, and it is no easy matter to determine whence the greenstone and basalt forming these dykes was derived.

"Are we to suppose, like some of the elder geologists, that a zone of trap is uniformly spread out beneath the granitic series, which composes, as far as we know, the foundations of the earth's crust? Is it not more probable that these dykes have been formed by fissures penetrating into partially-cooled rocks of the granitic and metamorphic series, and by their more fluid parts, consisting chiefly of hornblende, oozing out and being sucked into such fissures? At Bahia, in Brazil, in a district composed of gneiss and primitive greenstone, I saw many dykes of a dark augitic or hornblendic rock, which, as several appearances clearly proved, either had been formed before the surrounding mass had become solid, or had, together with it, been afterwards thoroughly softened. On both sides of one of these dykes the gneiss was penetrated to the distance of several yards by numerous curvilinear streaks or threads of dark matter, and some few of these threads could be traced to their junction with the dyke. When examining them I doubted whether such hair-like and curvilinear veins could have been injected; and I now suspect that, instead of having been injected from the dyke, they were its feeders. If the foregoing view of the origin of trap-dykes in widely-extended granitic regions, far from rocks of any other formation, be admitted as probable, we may further admit, in the case of a great body of plutonic rock being impelled by repeated movements into the axis of a mountain chain, that its more liquid constituent parts might drain into deep and unseen abysses, afterwards perhaps to be brought to the surface under the form either of injected masses of greenstone and augitic porphyry, or of basaltic eruptions. Much of the difficulty which geologists have experienced when they have compared the composition of volcanic with plutonic formations, will, I think, be removed, if we believe that most plutonic masses have been, to a certain extent, drained of those comparatively weighty and easily liquified elements which compose the trappean and basaltic series of rocks." (p. 124.)

The distribution of volcanic islands scattered through the great oceans which cover so large a proportion of the earth, becomes a matter of interest when we consider it with reference to the rest of the islands in those seas and the other volcanic districts of the globe. With the exception of some islands of large size, as New Zealand (which, however, contains volcanoes), the Falkland Islands, near the coast of South America, New Caledonia (a large island), the Seychelles, situated in a line prolonged from Madagascar, and

one or two others, the vast and almost innumerable multitude of islands scattered throughout the Pacific, the Indian, and the Atlantic Oceans are all composed either of volcanic or of modern coral rocks (p. 125). This fact, singular as it is, is a manifest extension of that law and the effect of the same causes, whether chemical or mechanical, from which it results that a vast majority of the volcanoes now in action either stand as islands in the sea or are near its shores.

“This fact of the Ocean islands being so generally volcanic is also interesting in relation to the nature of the mountain chains on our continents, which are comparatively seldom volcanic, and yet we are led to suppose that where our continents now stand, an ocean once extended. Do volcanic eruptions, we may ask, reach the surface more readily through fissures formed during the first stages of the conversion of the bed of the ocean into a tract of land?” (p. 126.)

In the volcanic archipelagos the islands are generally arranged either in single, double, or treble rows in lines which are frequently curved in a slight degree. This arrangement in lines seems to exist in a perfect series from a few volcanic islands placed in a row, to a train of linear archipelagos following each other in a straight line, and so on to a great wall, like the Cordilleras of America. Along the shores of great continents also there exist islands forming small volcanic groups, indicating, it would seem, a relation, not only by proximity but in the direction of the fissures of eruption, to the neighbouring continents, and in some cases affected by the same volcanic disturbances. The lines of intersection at the Galapagos, at the Cape de Verde archipelagos, and the best marked line of the Canary Islands, are examples of this relation, and in some of these cases eruptions have taken place within the historical period on more than one of these parallel lines of fissure. “Believing,” says Mr. Darwin, “that a mountain axis differs essentially from a volcano, only in plutonic rocks having been injected instead of volcanic matter having been ejected, this appears to me an interesting circumstance; for we may infer from it as probable, that in the elevation of a mountain chain, two or more of the parallel lines forming it may be upraised and injected within the same geological period.” (p. 129.)

D. T. A.

II. *Physical description of NEW SOUTH WALES and VAN DIEMEN'S LAND, accompanied by a Geological Map, Sections and Diagrams, and figures of the organic remains.* By P. E. de STRZELECKI. 8vo. pp. 462.

THIS work by the Count de Strzelecki is the result of five years of continual labour occupied in travelling, on foot, for a distance of as much as 7000 miles, through various parts of the eastern shores of the vast island-continent of Australia and in the island of Van Diemen's Land. The main object of the author's visit to New South Wales, he states to have been to examine its

mineralogy; but the materials he met with for this purpose were too few and too little important to satisfy his curiosity, and he turned therefore to the wider field of investigation presented by its geological structure, and has endeavoured by a map, coloured in a certain sense geologically, by a number of sections, and by description, to communicate information on this subject. The map includes a district of about 150 miles in New South Wales, measuring inland from the sea-coast from the 30th to the 39th degrees of south latitude, and the whole of Van Diemen's Land, the author stating that he was induced to continue his investigations southwards into that island, and include it in his geological survey, in consequence of the great similarity of its general structure to that of the main land.—We shall endeavour in the present article to deduce a general account of the geology of the district without confining ourselves to the exact order of arrangement adopted by the author.

The physical features of the eastern coast of Australia appear to be derived from a great number of sharply-defined elevations, producing a multitude of ridges which have a general direction from N. E. to S. W., and which are sometimes broken through and occasionally connected by transverse ridges. Very numerous and prominent spurs project as it were on the eastern face of these principal lines of elevated ridges, and the natural result of a conformation so peculiar is the existence of many yawning chasms, deep winding gorges and frightful precipices, forming an endless labyrinth of almost subterranean gullies, exceedingly difficult to penetrate, and rendering the whole tract intricate and broken. A similar structure is said to extend also to the west of the mountain range.

The altitudes of the higher points of these ridges, which are for the most part peaks of striking shape and lofty elevation, range in the more northern district, as in latitude 30°, from 2400 to 4700 feet. Towards the south, in the district known as the Australian Alps, one peak called Mount Kosciuszko attains the height of 6500 feet, and the chain there trends greatly towards the west until it turns again southwards and terminates in the sea at Wilson's Promontory. The same structure is however continued across Bass's Straits, by a chain of islands, and forms a lofty and picturesque mountain district in the north-eastern extremity of Van Diemen's Land.

The central axis of the whole district thus remarkably characterised consists, it would appear, invariably of igneous rocks, and chiefly of granite, syenite, and quartz rock. Of these granite is described as constituting "nearly the entire floor of the western portion of New South Wales, to the complete exclusion of mica slate and gneiss, and extending far into the interior of New Holland, in masses of mammillary, tuberos, globular or botryoidal form." (p. 85.)

The forms of the mountain summits mark by their deep, jagged, dentated, and serrated outline the nature of the rocks which crown

the different ranges; and the condition of the granitic and porphyritic rocks, as they appear in Van Diemen's Land, is picturesquely illustrated by the following description of the mountain scenery viewed from the lofty, craggy, and precipitous battlements of Ben Lomond.

"The northern extremity of the mountain overhangs profound tortuous abysses, and commands an uninterrupted view of Ben Nevis, Mount Barrow, Mount Arthur, Mount Cameron, the northern coast, and the most conspicuous peaks of the islands of Bass's Straits.

"From the southern side is seen the whole eastern labyrinth of ridges and chasms, the fertile valley of the Break o' Day, together with the beautiful outline of the bays and promontories of the eastern coast.

"The central part of the mountain's top, as the spectator recedes from the verge of its precipitous flanks, offers, again, views which have nothing in common with those already described. The scene is here one of unbroken solitude, silence, and desolation. On the bare earth, covered only here and there with patches of snow in the midst of summer, thousands of prismatic green-stone columns (of eight or ten feet in diameter) lie prostrate at the foot of the traveller; columns of gigantic order, chiselled by Nature, and raised by her hands to this majestic elevation, where, overthrown and broken into huge fragments, their ends project over chasms 3000 feet in perpendicular depth.

"From this table-land, however, of the mountain's summit, the fearful gorges, precipitous cliffs, and inaccessible ridges of its immediate vicinity disappear; while the distant masses of the western hills seem blended or levelled into one undulating valley, intersected by the windings of glittering streams of the valley of the Tamar, and bounded, on the remotest skirt of the horizon, by a finely-drawn chain of mountains."

The metamorphic rocks of the district described by M. de Strzelecky consist of a small development of mica schist and siliceous slate, together with a little clay-slate, all of which occur in vertical strata, and occasionally flank the igneous rocks, the mica slate being the undermost and being succeeded first by the siliceous and then by clay-slate. Besides these many parts of New South Wales exhibit metamorphic rocks consisting of different kinds of granular marble and limestone, some of which are very beautiful, and are available for statuary and other ornamental purposes.

The fossiliferous stratified rocks of New South Wales and Van Diemen's Land appear to be chiefly referable to the Palæozoic period. They form two groups, the lower including the middle and perhaps the older Palæozoic rocks of other parts of the world, and the upper those of the carboniferous or newer Palæozoic period. The subdivisions have not been very minutely traced; and although of the main facts there can be little doubt, it is somewhat to be lamented that the descriptive geology of the older of these groups has not been hitherto so far worked out as to render it possible to trace with any degree of accuracy even the position of the beds at the surface.*

* So far as one can judge, the rocks on the eastern flanks of the syenitic chain occupying the western district of Van Diemen's Land, and those at Yass Plains and Shoalhaven, in New South Wales, would seem to belong to the older period; but in these, and in most of the localities mentioned by the author, fossils of the carboniferous series are chiefly prevalent. — Ed.

Viewing, however, the Palæozoic rocks of New South Wales and Van Diemen's Land as a whole, and with reference to the fossil fauna, so far as it is hitherto known, we may remark, first, the extreme poverty of the different beds in this respect, in so far as species are concerned—the whole number hitherto determined not exceeding 48—and, next, the mode of their distribution and the relative proportion referable to the various natural families. We learn from the work before us that of the whole number of species there are 10 *Polyparia*, 14 *Conchifera*, 12 *Brachiopoda*, 7 *Gasteropoda*, 1 *Heteropod*, 2 *Pteropoda*, and 2 *Crustacea*, besides some remains of fishes. Considered locally there is a preponderance of bivalve mollusca and Gasteropods in the Illawara district (N. S. Wales), leading us to suppose that the deposits there may have been littoral or accumulated at no great distance from the ancient shore. On the other hand, the coarse sand rock of Raymond Terrace appears to have been rather unfavourable to the existence of animal life, while the Booral deposit is interesting as pointing to a different state of things. This latter is a dark flaggy rock, a bituminous limestone, containing numerous remains of species referred to *Littorina* and *Turritella*, with fragments of *Ichthyodorulites* and abundant traces of the minute crustacean genera *Bairdia* and *Cithere*; the latter forming regular layers in the limestone, just as they are found deposited in the carboniferous shales near Halifax, in Yorkshire, in other parts of England and in Ireland.

“ In Van Diemen's Land, where the strata are extremely variable, the chief fossiliferous deposit appears to be Mount Wellington and some adjacent localities: in these we find the different species of *Brachiopoda* attaining a much greater numerical developement than in the corresponding series on the Australian continent; the *Productus brachytherus*, *Spirifer avicula*, *S. vespertilio*, and other species, are extremely abundant, some of them being of considerable size. Associated with these are numerous traces of fine and large specimens (in some places filling the rock in every direction) of the different species of *Polyparia*, as *Stenopora ovata* and *S. Tasmaniensis*, *Fenestella ampla*, *F. internata*, *F. fossula*, &c.; while the remains of *Conchifera* and *Gasteropoda* are but rarely to be discovered; the locality at Spring Hill containing the largest proportion, with one species of *Polyparia*, the *Stenopora informis* (Lonsdale).

“ In comparing these forms with those from the Palæozoic series of other countries, we find some of them to be identical, and others to be representative species: the *Terebratula hastata* is the same as the English species; there is a *Spirifer* near to *S. glaber* (Mart.); the *Littorina filosa* is very closely allied to, if not identical with *Loxonema sulcatula* (M'Coy); and the *Turritella trilineata* approximates to *T. acicula* (Phillips). Of representative forms, we have the *Spirifer crebristria*, allied to *S. glabristria* (Phil.) and *Athyris depressa* (M'Coy); the *Sp. Tasmaniensis*, to the *S. Pentlandi* (D'Orb.), from the carboniferous limestone of Bolivia; and the *Sp. Stokesii*, near to a Kendal species. Of the winged Spirifers, the *S. avicula* and *S. vespertilio* belong to the group of *S. convoluta* (Phil.), and *S. extensa* (Sow.); and a variety of the *S. vespertilio* is very near to the *S. condor* (D'Orb.), from the carboniferous deposit of Bolivia; and another to the *S. Lyellii* (De Verneuil). The Australian *Productæ* are allied to the English forms of that genus. Of the *Polyparia*, the *Fenestella* generally appear to be the representatives of some English and Irish species.

“ Having thus briefly alluded to the local distribution and general resemblances of the Australian Palæozoic fauna, it is important to remark the absence

of certain genera (so far at least as our observations on different collections have extended) which are abundantly distributed in the equivalent deposits of northern Europe. Of the family *Cephalopoda*, no traces of the *Nautilus*, *Clymenia*, or *Goniatites* have hitherto been detected; nor have there been found any remains of the true *Leptæna*, or scarcely of *Orthidæ* (one doubtful fragment from Booral excepted), genera so characteristic of the Devonian and carboniferous strata of other countries. *Trilobites* appear to have been equally rare; and the Crustacean family is represented by two or three species belonging to Cypridiform genera. On the other hand, the presence of a species of *Bellerophon* and *Conularia*, seven or eight of *Spirifer*, and two or three belonging to the gibbose species of *Productus*, — the latter being forms generally found in the carboniferous limestone, — and these associated with carboniferous types of *Polyparia* and a few allied forms of *Conchifera* and *Gasteropoda*, — lead us to believe that the deposits containing them may probably belong to that division of the Palæozoic series usually termed carboniferous.

“The above observations apply chiefly to the great mass of ancient fossiliferous strata of these countries; but it also appears, from the evidence of superposition brought forth in the geological section, as well as by the fossil remains contained therein, that the deposits at Yass Plains and Shoalhaven, in New South Wales, are anterior to the other strata, and may probably be considered the equivalent of the Devonian system of Europe. The fossil species from these deposits are but imperfectly known: *Favosites Gothlandica*, another species of *Favosites*, and *Amplexus arundinaceus* (Lonsdale), fragments of *Orthoceras* and remains of *Trilobites*, have only at present been noticed. Thus, the Palæozoic series of Australia and Tasmania may be regarded as partly the equivalent of the Devonian and carboniferous system of other countries.

“I cannot conclude these brief notes without remarking that many forms in these deposits may have been obliterated; and others so considerably altered, that it is rather difficult to institute careful comparisons, from the metamorphic action that has been induced on many of the strata by the intrusion of trappean dykes, which appear to have been more frequent in Van Diemen's Land than in the corresponding series on the Australian continent.”

The rocks of the carboniferous period, characterised by the presence of coal and occurring in New South Wales and Van Diemen's Land, are considered by the author as belonging to a period somewhat more recent than that just described. However this may be, the coal-bearing deposits are sufficiently important in themselves to demand careful attention.

There appear to be three basin-shaped deposits of this kind which are described by M. de Strzelecky under the names of the Newcastle, the South Esk, and the Jerusalem Basins respectively. Of these the first mentioned is in New South Wales, and the two latter in Van Diemen's Land.

The Newcastle (N. S. W.) coal field occupies a tract, of which the dimensions are not given, extending for some distance on both sides the stream in the basin of the Hunter River near its mouth, in about 33° S. lat. The northern limits of this basin consist of a coarse sandstone, containing *Conulariæ*, *Spirifers*, and *Productæ*, having a southerly dip and resting on a conglomerate. The southern limits are composed of masses of fine-grained sandstone of a different kind, containing mica and iron glance, interspersed with very thin seams of coal. Still further to the south, at Lake Macquarie, coal crops out from beneath this sandstone.

The coast line from Lake Macquarie northward gives a con-

tinuous section of the sequence of the coal-bearing beds in a cliff about 200 feet high, and along a distance of nearly half a mile. The beds are affected by numerous faults. The coal is worked between this point and Lake Macquarie, and the author gives the following as the shaft section not far from the cliff:—

	Feet
1. Conglomerate - - - - -	23
2. <i>Coal</i> - - - - -	3
3. Cherts and gritstones with angular fragments of flint intermixed with thin veins of coal - - -	44
4. <i>Coal</i> - - - - -	5
5. Clay rock of greyish colour and bluish shale with impressions of ferns - - -	43
6. <i>Coal</i> - - - - -	5
7. Greenish sandstone with blue veins - - -	25
8. <i>Coal</i> - - - - -	3
9. Greenish sandstone - - - - -	50
10. <i>Coal</i> - - - - -	3

Inland and southwards the upper beds are seen to dip westward under masses of variegated and fine-grained sandstone, conformable with the coal deposits.

The South Esk Basin (V. D. Land), although much broken and apparently very limited in extent, agrees with that of Newcastle (N. S. W.) in its general geological characters. A variegated sandstone overlies the regular coal measures.

The Jerusalem Basin (V. D. Land) is situated not far from Hobart Town to the east. The underlying bed is a limestone, containing *Productæ* and *Spirifers*, succeeded by a conglomerate, on which the coal-measures repose. The beds dip to the south, and the following is given as the shaft section of the Jerusalem pits:—

	Feet
1. Sandstone with impressions of ferns - - -	13
2. Greenish sandstone - - - - -	3
3. Clay slate (? shale) - - - - -	1
4. Grey clay - - - - -	2
5. Blackish clay with impressions of ferns - - -	2
6. <i>Coal</i> - - - - -	3
7. Greyish clay - - - - -	12
8. Blackish clay with ferns - - - - -	3
9. Greyish clay - - - - -	11
10. Blackish clay with ferns - - - - -	6
11. <i>Coal</i> - - - - -	2

Some of the coal in the Jerusalem Basin is described as anthracitic.

Besides these localities the existence of coal is known at Port Western (N. S. W.), (lat. 38°30' S., long. 145° W.), at Moreton Bay, and at the head of the rivers Hastings and Mac Leay, north of Newcastle. Partial outcrops have been also observed in the Vale of Clywd, north of Mount York, and east of Mount Clarence. These possibly belong to the Newcastle Basin.

The fossil plants obtained from these coal-measures, and de-

scribed in the work before us, are but few. They are referred by Mr. Morris (who has assisted the author in this part of his work) to three species of *Sphenopteris*, one *Glossopteris*, two *Pecopteris*, one *Zeugophyllites*, and one *Phyllothea*.

"In reviewing the few species of the ancient flora that have been hitherto collected from the carboniferous deposits of Australia, including therein the fossil plants from the basin of the Hunter, in New South Wales, and those from the Jerusalem basin, in Van Diemen's Land, we at once perceive the interesting fact, that although limited as the species are in number, there is no trace of any of those remarkable genera so characteristic of, and so abundant in, the strata of the European and American coal-fields, such as *Lepidodendron*, *Sigillaria*, *Stigmara*, *Calamites*, or *Conifera*.

"The basins themselves, if indeed contemporaneous, appear to be characterised by a distinctly localised flora; no species, as far at least as our observations have extended, being found common to the two deposits. The basin of the Hunter contains *Phyllothea australis*, *Glossopteris Browniana*, and some other species; in that of Jerusalem, in Van Diemen's Land, are found three or four species belonging to the genera *Sphenopteris* and *Pecopteris*, and one to *Zeugophyllites*, these being associated with some large fragments of stems, too imperfect to be defined.

"In comparing, therefore, the whole of the species at present known, from these deposits, with the coal plants of Europe, there appears, indeed, to be but few, if any, analogical forms, although the equisetoid-looking *Phyllothea* may probably be considered as the representative of the *Calamites* of the northern deposits; while, on the other hand, its congener, the *Glossopteris Browniana*, is a fern so entirely different from any of those that are found in the carboniferous periods of the northern hemisphere.

"Among the fossil plants collected from the Jerusalem basin, we find the interesting genus *Zeugophyllites*, and certain forms of *Pecopteris*, one of which is closely allied to an oolitic species, and another having strong resemblances to an *Odontopteris* from the Permian system of Russia.

"These few observations partly lead us to infer that the flora of the southern hemisphere was perfectly distinct in its facies from the northern, at the carboniferous period; just as, at the present time, the modern flora of the same continent presents a striking difference to that of other portions of the globe; and this appears to be the more remarkable, as the species constituting the fauna of the Australian ocean, anterior to that period, contain many forms which, if not perfectly identical, are at least the representative ones of those of the northern region.

"In instituting a comparison between the species collected from the Australian deposits, and those described from the Burdwan coal-field by Professor Royle, we observe both the remarkable analogy of form of some species and the actual identity of others; from which we may probably be led to infer that the deposition of the strata containing them was not only contemporaneous, but that the conditions of the flora of some portions of the Indian and Australian continents, at that epoch, were not very dissimilar. In the Burdwan coal-field we find the *Pecopteris Lindleyana*, *Glossopteris danæoides*, *G. Browniana*, and other plants associated with two species of a very curious form, *Vertebraria indica* and *V. radiata*. The Australian deposit also contains *Glossopteris Browniana*, two or three species of *Sphenopteris*, and the same species of *Vertebraria* above noticed. The *Pecopteris australis* of the Jerusalem basin is closely allied to, if not identical with, the *P. Lindleyana* from Burdwan. The *Glossopteris danæoides* of the Burdwan deposit apparently belongs to the genus *Teniopteris*, the veins being perfectly horizontal, and not anastomosed, as in the typical species of *Glossopteris*. We have previously remarked upon the absence of certain carboniferous forms in these deposits; on the other hand, if we compare some of the species with certain others, from the oolitic series of England, a striking analogy of form is at once perceptible; the *Pecopteris Murrayana*, *P. Whitbiensis*, and *Glossopteris Phillipsii* representing as it were the *Pecopteris* (*Sphenopteris*) *alata*, *P. australis*, and *Glossopteris Browniana* of the Australian strata."

It would seem that in those parts of Australia described by the author there is no appearance of any rocks of the secondary period, or even of the early or middle part of the tertiary period. Of the newer tertiary, and perhaps almost the recent period we find some interesting marks in the raised beaches disposed at intervals along the present coast line, in the osseous breccia of the caverns, and in the remarkable fossil trees spread over the surface in some of the valleys, especially in Derwent valley (Van Diemen's Land). The raised beaches contain shells of species still common on the coast: the breccia have supplied Professor Owen with the materials of a Report on the extinct mammalia of Australia and a supplement to that Report, both published in the volumes of the Proceedings of the British Association (1844, 1845), and the remarkable opalized trees have been recently described by Dr. Hooker, the naturalist in the expedition of H. M. S. Erebus.

The gravel of the valley of the Derwent is however hardly less striking than these fossil trees. It consists of a multitude of "boulders composed of cylindrical, somewhat flattened columns of basalt confusedly heaped together with detritus of pebbles mixed with spheroid boulders of greenstone rock, all lodged against an escarpment situated at the bottom of the valley, and on the right bank of the Derwent." (p. 148.) The escarpment is formed of carboniferous rocks, and has been violently rent asunder probably by volcanic disturbance of no very ancient date.

Much still remains to be effected by careful and minute observation, and much also in the way of generalisation, before the geological structure of the eastern portion of Australia can be brought into relation with that of districts at present more minutely and clearly made out. Meanwhile, the gradual development of facts bearing on the condition of the eastern and southern continents during the secondary and early tertiary period cannot fail to suggest hypotheses with regard to the condition of the land in these parts of the world, the determination of which may greatly influence the views of geologists concerning European and American geology.

D. T. A.

V. MISCELLANEA.

I. DISTRIBUTION of FOSSIL PLANTS.

[THE following extract, from a memoir by M. Gœppert, of Breslau, well known for his investigations concerning the fossil remains of vegetables, possesses great interest as offering a general view of the relative distribution of these remains. In the year 1828, when a summary of this kind was last given by M. Ad. Brongniart, only 500 species were known. The present list includes 1792.—ED.]

	Families.	Species.
Grauwacké (beds older than those of the carboniferous series) - - - - -	8	52
Carboniferous limestone - - - - -	3	3
Coal measures - - - - -	18	816
Lower new red sandstone (Permian) - - - - -	4	39
Magnesian limestone and Kupfer schiefer (Permian) - - - - -	3	19
	— 36	— 929
Gres bigarré (Bunter sandstein) - - - - -	8	32
Muschelkalk - - - - -	2	2
Keuper marls (Marnes irisées) - - - - -	8	52
Lias - - - - -	12	75
Oolitic series - - - - -	9	159
Wealden formation - - - - -	8	16
Lower cretaceous beds - - - - -	15	59
Chalk - - - - -	1	3
	— 63	— 398
Monte Bolca beds (Lower Tertiary) - - - - -	4	7
Other Lower Tertiary - - - - -	10	120
Middle and Upper Tertiary (Miocene and Pliocene) - - - - -	52	327
	— 66	— 454
Unknown geological position - - - - -	4	11
	— 169	— 1792

II. NOTICE of a MASTODON recently discovered in NORTH AMERICA.

“THE remains of an immense *Mastodon* have been lately discovered and exhumed about 6 miles west of Newburgh. This is the fourth skeleton of the kind that has been discovered in this country; but while all the others have been imperfect (many of

the bones never having been discovered) this one is entire, every bone having been found, even to the small bones of the feet and tail, and in a complete state of preservation, the enamel on the teeth being as perfect as if in the mouth of a living animal. An idea of the size of the monster may be formed when I state that the skull alone weighs 700 lbs. The tusks are over 9 feet long. Across the hip bones he measures about 7 feet. The position of the animal at death was clearly discernible. He had evidently become *mired*, and had settled down on his haunches, with his fore legs spread out, and in this posture he was found. Under the vertebræ, the contents of his stomach were found, to the amount of several bushels, and consisted of leaves, twigs and fragments of the branches of trees, crunched and broken up. As the remains were found imbedded in marl, all this was entirely evident." (*Extracted from an American paper, dated August, 1845.*)

III. LOCALITIES of PALÆOZOIC FOSSILS in CORNWALL.

[12th Report of the Cornwall Polytechnic Soc., p. 66.]

[THE following list of localities in Cornwall from whence fossils have been obtained, may be a useful guide to collectors in a district where, till lately, organic remains were hardly known to exist. The memoir from which it is extracted is by Mr. C. W. PEACH, a most accurate and energetic labourer in the field of observation, and himself the first discoverer of the remains of fishes in Cornwall. — Ed.]

The Cairn in Gerran's Bay is hard quartz, and encloses *Actinocrinus* (very rare), *Leptæna* (very rare), *Orthis*, *Trilobites*, &c. The same sort of rock, likewise fossiliferous, passes through Veryan, by Portloe, and is again seen near Carhayes, and runs thence to Great Peraver, both in Goran. There is also a conglomerate in Goran, running by the side of the quartz rock, containing fossiliferous rounded limestones in which are great numbers of *Orthoceratites* and *Crinoidal Stems*, some of which are also loose in the softer part of the conglomerate.

At the Van, near the Black Head in St. Austell, are calcareous slates with *Turbinolopsis*, *Crinoidea*, and probably *Spirifers*; and beyond the Black Head, in a slate quarry, similar fossils with *Orthoceratites* and other specimens of a singular form. The cliffs from this spot to the entrance of Fowey Harbour, contain more or less of similar fossils, with *Fenestella*, *Spirifer*, &c. On the west side of Fowey Harbour, from the entrance to White House Ferry, and to the new road, the cliffs are quite fossiliferous, and consist of slate, sandstone, and limestone of various degrees of hardness, and contorted into singular forms. The fossils here are interesting,

and include *Turbinolopsis*, *Cyathophyllum*, *Favosites*, *Caunopora*, *Fenestella*, *Retepora*, and various *Crinoidea*; *Cucullea*, *Avicula*, *Leptæna*, *Orthis*, *Spirifer*; *Orthoceratites*, *Goniatites*, and *Trilobites*, together with a specimen or two of *Onchus*. The cliffs and quarries near Polruan, and thence to the harbour's mouth and to Lantick Bay, afford similar fossils in like abundance. At Polperro are the splendid fish rocks, and in these are *Cephalaspis*, and *Holoptychius*, with *Bellerophon* and *Turritella* of the Old Red Sandstone, and *Sphagodus* and *Onchus* of the Upper Ludlow rocks, with portions of teeth and probably Coprolites. The fish-bone bed extends from Ready-money Cove, Fowey Harbour, to beyond Talland sand, near West Looe.

There is also a hard calcareous rock with *Bellerophon*, &c., which extends from near Polperro, and may be traced across Talland Beach. Continuing the coast line from Talland sand to West and East Looe, thence to beyond Mellenðreth, near Seaton, and so on to Whitsand Bay, we find quartzose and clay slates, intermingled with limestones, all containing great quantities of fossils, similar to those of Fowey, &c. Leaving the coast and proceeding inland by the new road to Barcelona, near Pelynt, and then along the east side of the Looe to near Morval, the rocks are highly fossiliferous; and if we continue our journey inland to Menheniott, in the splendid slate quarry of Rose Vale, we find *Turbinolopsis*, *Crinoidea*, *Trilobites*, &c. Similar specimens in a similar rock are also found at Wade Bridge, on St. Breock and Withiel Downs, and, indeed, in various places in those vicinities; thus showing, since they are also found in similar slates containing limestones, on the north coast from Tintagel to beyond Newquay, that the fossiliferous beds extend through the country.

At Lower St. Columb, *Goniatites* and *Onchus* have been found, and, in addition to these localities, must be mentioned South Petherwyn, which supplied so many fossils described by Professor Phillips*, and Tintagel, not visited by the author.

The author has found similar fossils to the Cornish ones, *in slates*, at Millbrook, Baker's Place, and Sandy Cove, near Plymouth; Meadsfoot Sand, and the Bathing Cove, Torquay; and near Paington, in Devonshire.

* Palæozoic Fossils of Cornwall, Devon, and West Somerset.

END OF THE FIRST VOLUME.

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EXPLANATION
OF
FIVE PLATES OF LOWER GREENSAND FOSSILS,
TO ILLUSTRATE

A REPORT BY PROFESSOR EDW. FORBES,
ON THE COLLECTION OF LOWER GREENSAND FOSSILS,
IN THE MUSEUM OF THE GEOLOGICAL SOCIETY.*

PLATE I.

- Fig. 1. *Perna mulleti*, exterior of upper valve.
2. ——— hinge, and interior of upper valve.
3, 4. ——— stages of growth.

8. *Avicula lanceolata*.
9. *Gervillia linguloides*.
10. *Lima lingua*.
11. *Lima expansa*.
12. *Gryphæa harpa*. Var. γ *semiplicata*.

PLATE II.

- Fig. 1. *Solecurtus Warburtoni*.
2. *Tellina* ? *Vectiana*.
3. *Pholadomya Martini*.
4. *Venus Vectensis*.
5. *Venus Orbigniana*.
6. *Venus* ? *fenestrata*.
7. *Lucina* ? *solidula*.
8. *Cardium sphaeroideum*.
9. *Cardium Ibbetsoni*.
10. *Isocardia* ? *ornata*.

PLATE IV.

1. *Tornatella marginata*.
2. *Turbo* ? *munitus*.
3. *Solarium minimum*.
4. *Scalaria* ? *sp.*
5. *Rostellaria glabra*.
6. *Pterocera Fittoni*.
7a. *Cerithium turriculatum*.
7b. ——— Var. β *angustior*.
8. *Cerithium Neocomiense*.
9. *Cerithium Clementinum*.
10. *Cerithium Lallierianum*.
11. *Cerithium attenuatum*.
12. *Cerithium Phillipsii*.

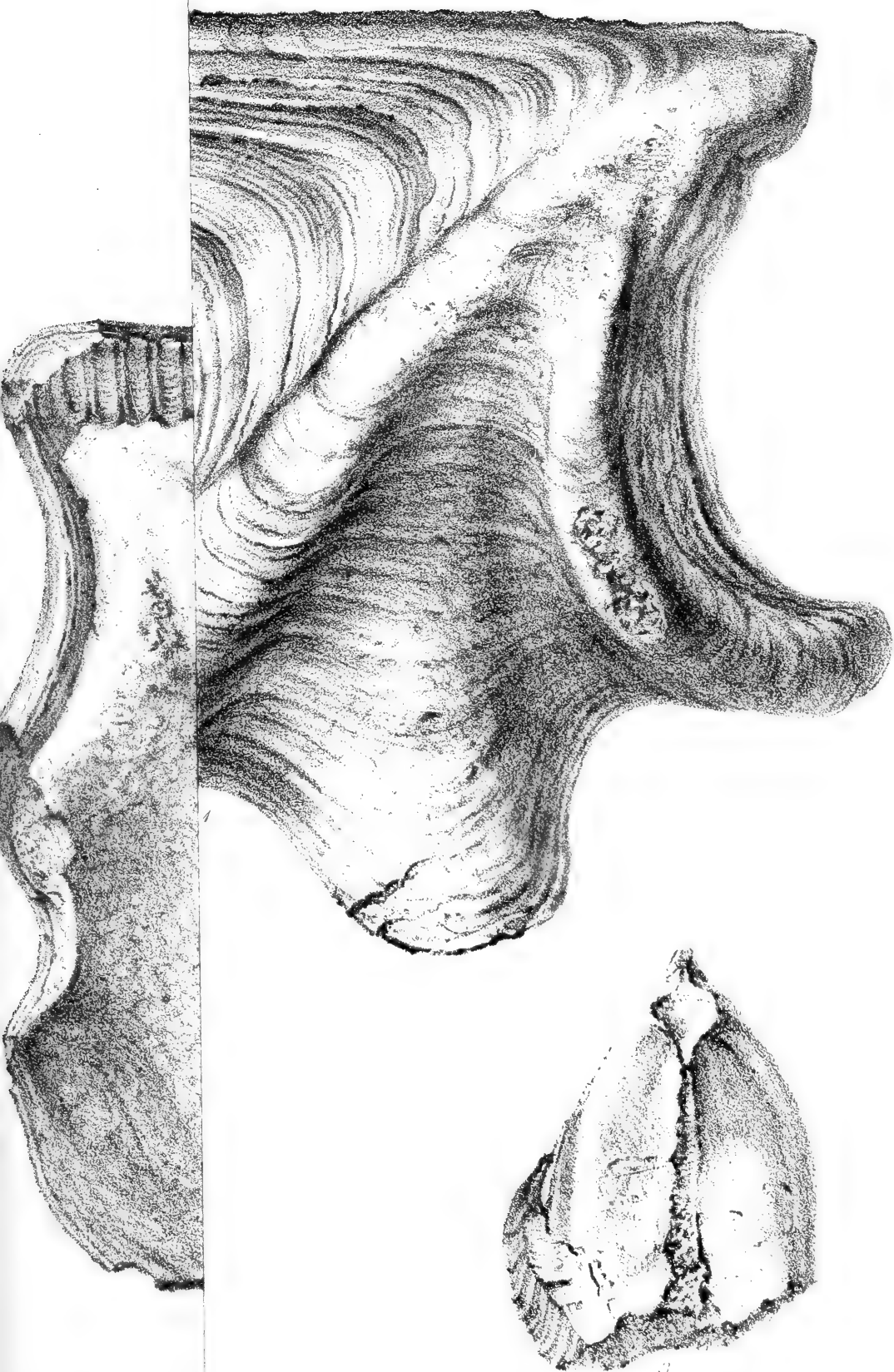
PLATE III.

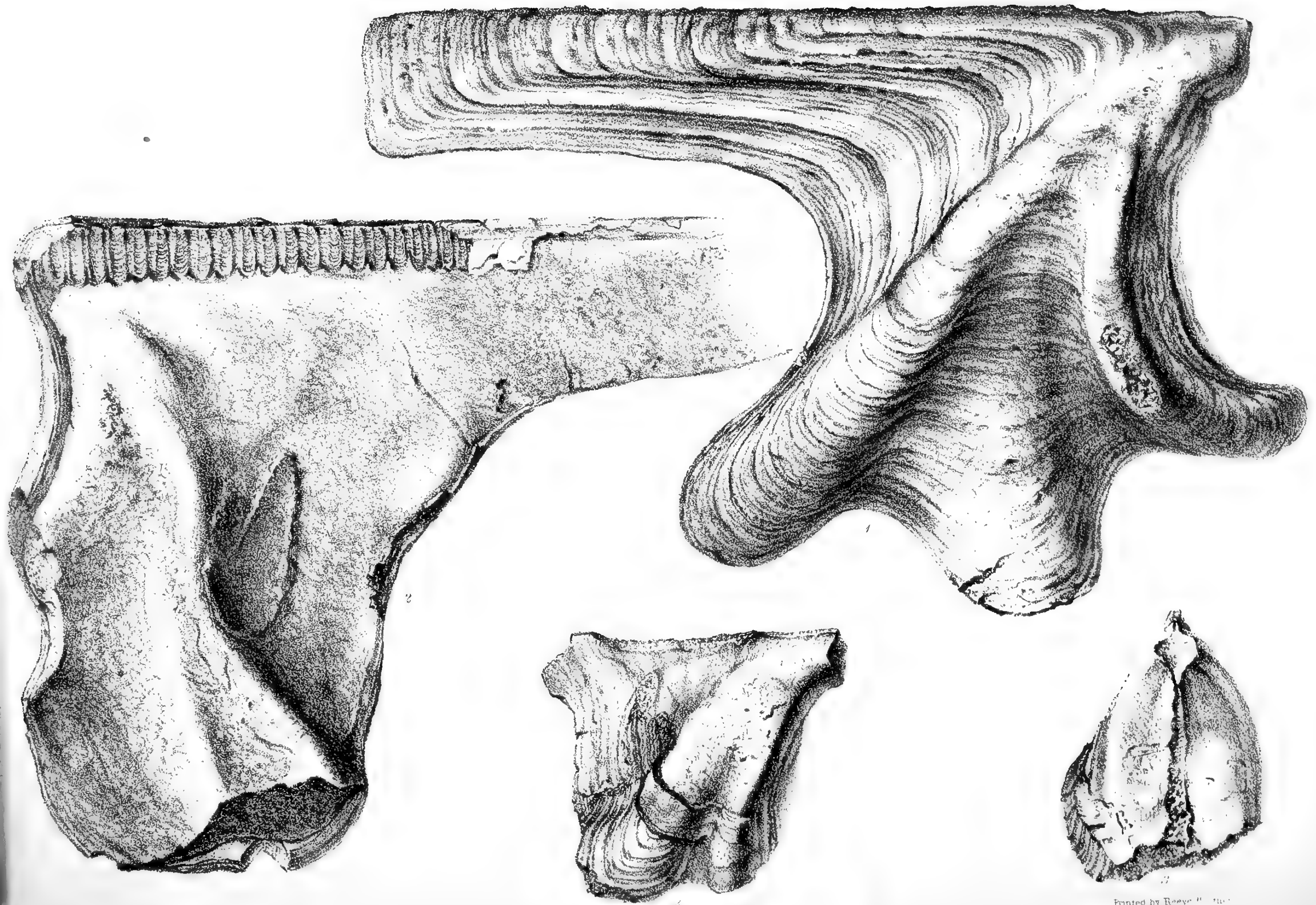
1. *Cypricardia undulata*.
2. *Perna alæformis*. Young ind.
3. *Cardium* [*Hemicardium*] ? *Austeni*.
4. *Nucula spathulata*.
5. *Arca exaltata*.
6. *Avicula ephemera*.
7. *Avicula depressa*.

PLATE V.

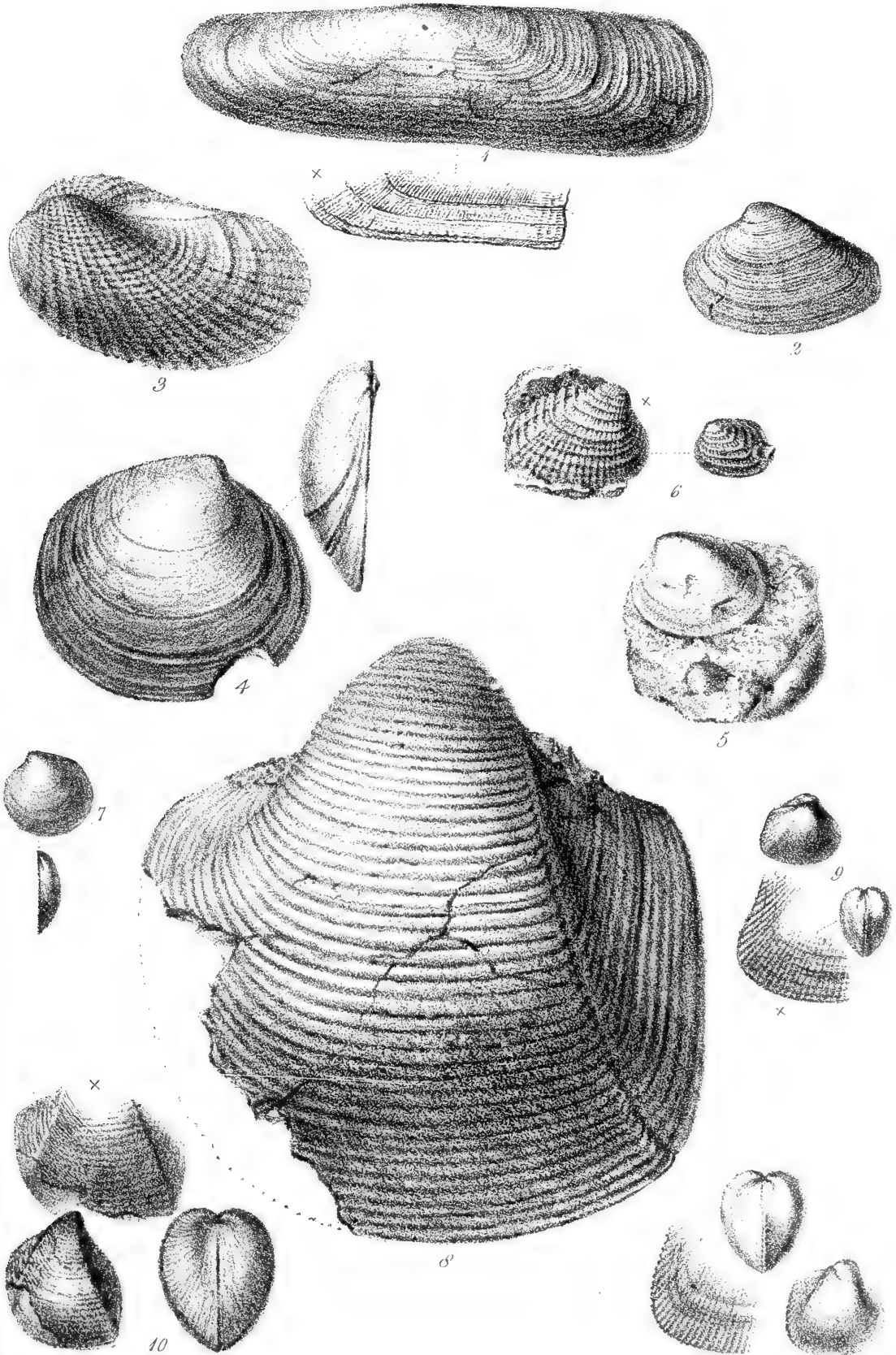
1. *Pleurotomaria Anstedii*.
2. *Ammonites Deshayesii*.
3. *Ammonites Martini*.
4. *Ammonites Hambrovi*.

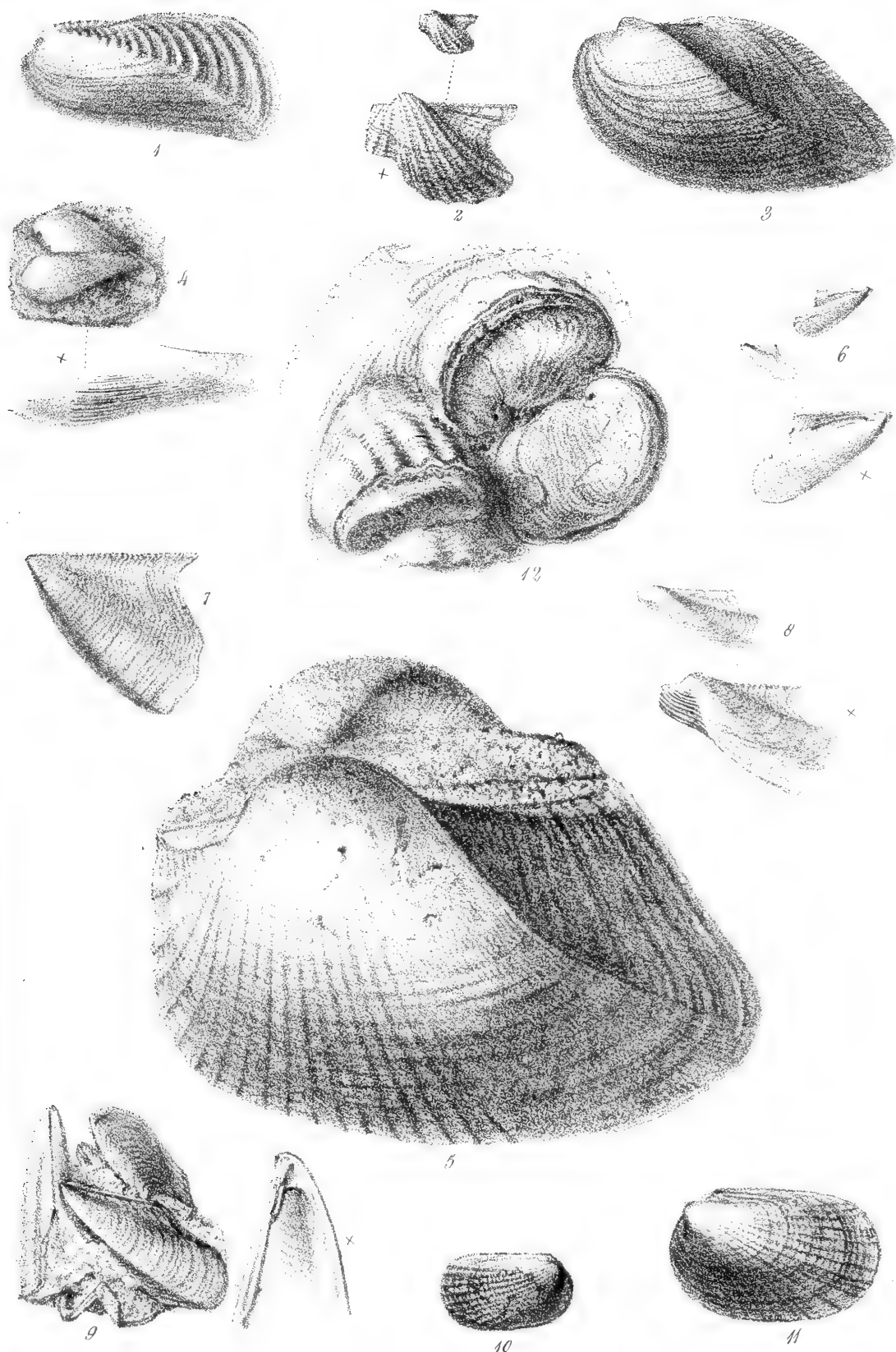
* The species printed in Italics have not before been figured or described.

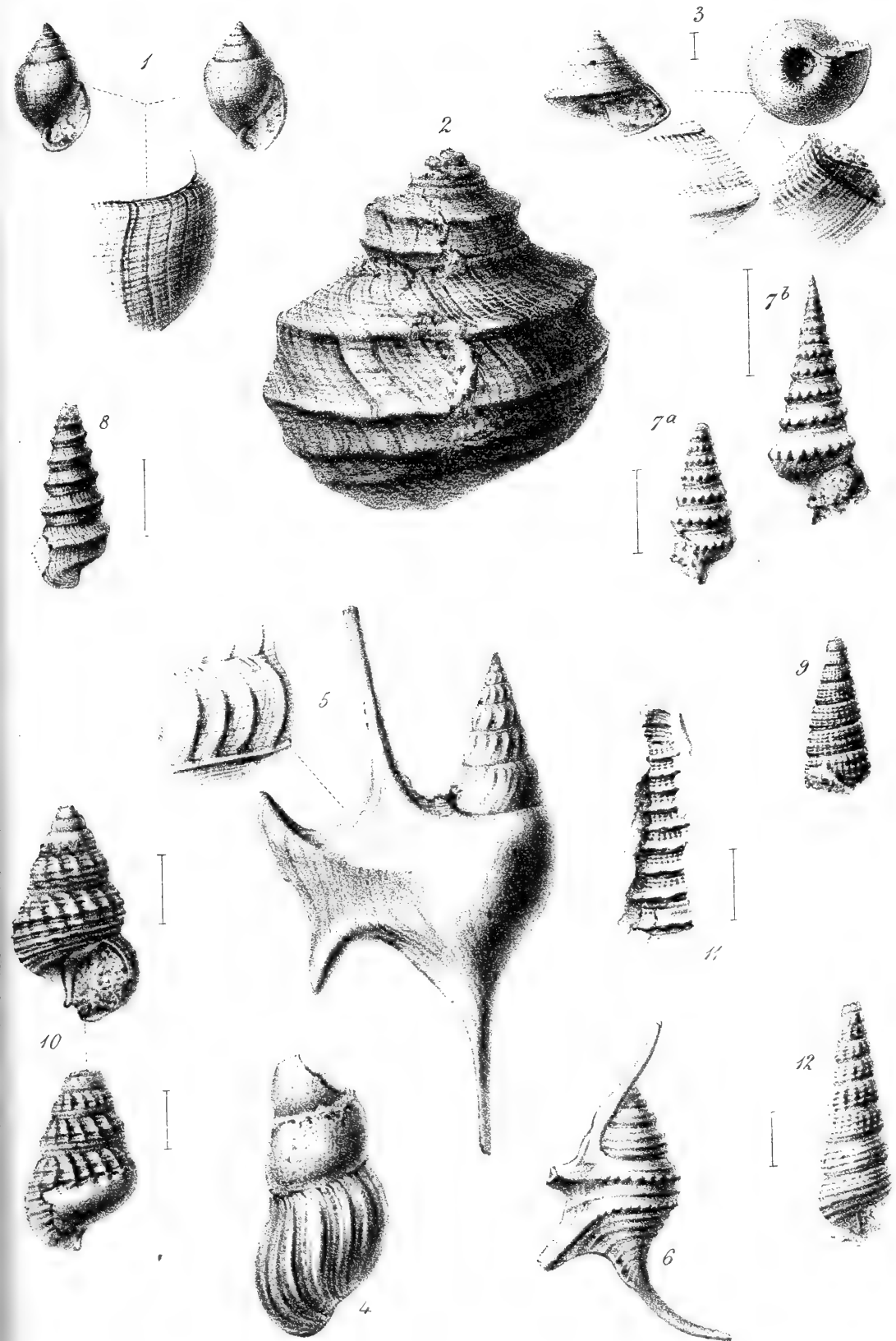




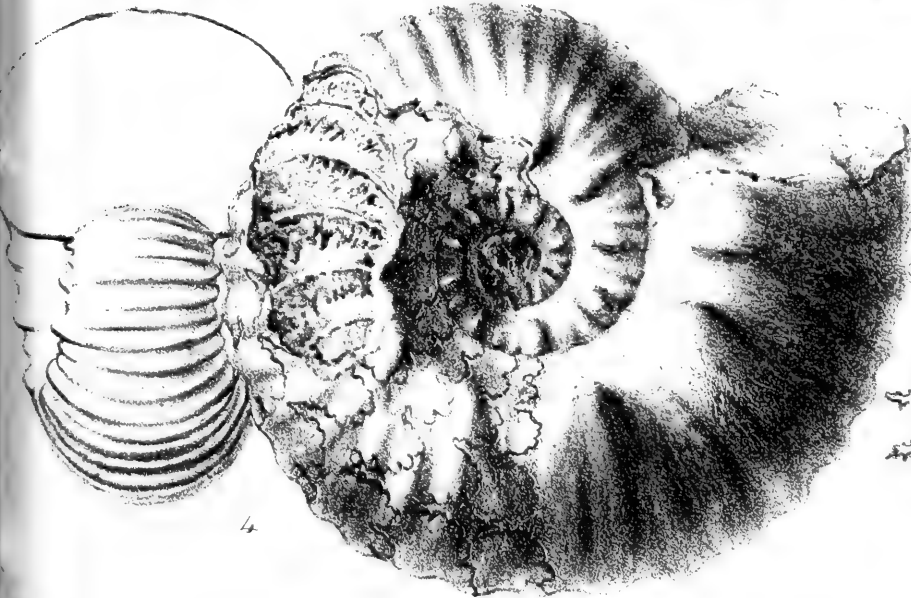
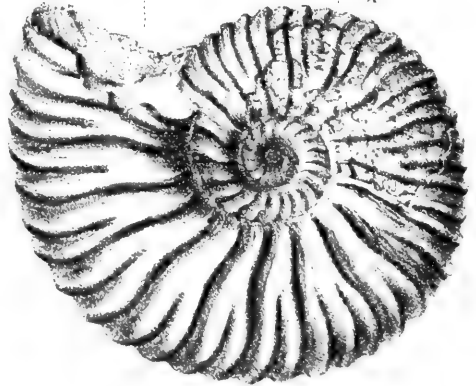
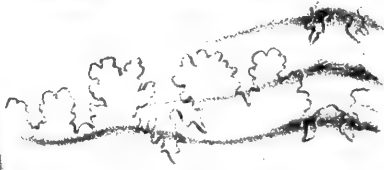
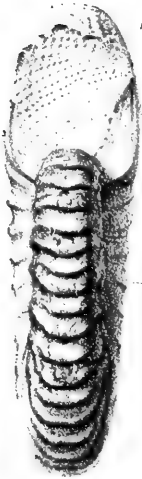
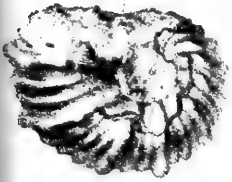
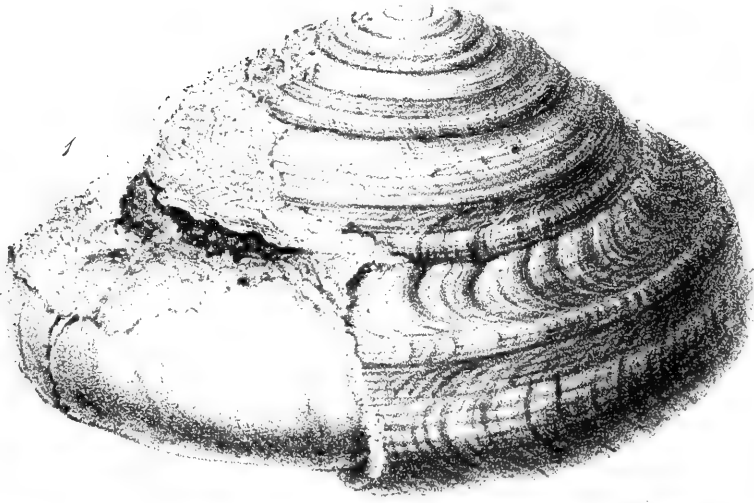
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* Referred to in the text by a mistake as *Silurian* fossils. See list of errata.

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